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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVII, No. 6 JUNE, 1917 WHOLE No. 143

A MATHEMATICAL VICTORY.

A Play in Two Acts.

Written under the auspices of the Mathematics Club of the Los Angeles State Normal School of California, those contributing especially being:

PHILIPPI H. HARDING, JEANNETTE BOWER,
MILDRED TRAVIS, KATHERINE HEGEMAN,
STELLA CHAMBERLEN.

ACT I.

Scene I.

EGYPT—Court of Sesostris.

Characters: ***Sesostris; Vellah,*** the King's spokesman; ***Mendez,*** overseer; ***Geometry,*** a priestly man; ***slaves, priest.***

Vellah. Mendez, step forth. The great, all-powerful, and wise Sesostris, our master, commands you to measure out by how much the land has become smaller. The ever-shifting Nile snake has eaten from the lands of his people. It is his most sacred and far-seeing Justice which decrees that the tax should be lessened for each person, according to the amount of his original quadrangle that has been devoured by the floods. Go, ye, therefore, and see that thy slaves do the work as commanded. ***(Overseer bows himself out.)***

(Sesostris issues orders to spokesman who then commands slaves, during the following monologue.)

Geometry. Aye, and it is only because of my instructions that that common Mendez can make the measurements as commanded. It is we of the sacred priesthood only who know all things. Much of my knowledge I do not give; it would not be understood.

(A slave speaks to Vellah, who bows before Sesostris.)

Vellah. Oh, great master of our land, the high priest, Ramosestris, of the temple of the most wise and learned god, Theuth,

to whom the Ibis is ever sacred, asks an audience with thee on matters of high import.

Sesostris. Let him approach.

(Priests enter.)

Ramosestris. Oh exalted and just ruler, we bring thee greetings from Theuth, the most wise god, inventor of many arts. We bring thee tidings which are of deep importance, and we would, therefore, beg that thy slaves be dismissed.

(Slaves go out, leaving priests, Geometry, Vellah, and Sesostris.)

Ramosestris. (*Unfolding papyrus scroll.*) One of our brothers has discovered, in an ancient and unknown cavity of the sacred altar, a scroll, written by a great scholar, Ahmes, containing deep learning. Our brother, Geometry, is very wise and can measure thy lands—

Geometry. (*Interrupting.*) Aye, and I can make a right angle by the stretching of ropes. See! (*Illustrated by three players with rope.*) And I can find the area of any piece of ground. (*Illustrated by an isosceles triang'e formed by players, number of persons on base times number of persons on one side equals the area.*) No one can do more.

Ramosestris. Yea, but in this "Directions for Obtaining the Knowledge of all Dark Things," one may read the instructions for performing all such marvelous computations; and, besides, there is a table giving the values of fractions; and in this great work, an *unknown* number can actually be found if you know what the sum of it and one of its parts is. Aye, 'tis a great work which we have discovered, and will mean much power for us. And you, Geometry, this means that it is time you worked out something *new;* your offering to knowledge is ancient.

Geometry. (*He has been growing less proud during this revelation, and now throws himself on his knees before Sesostris.*) Oh, great master, I do now realize how little I know. But I vow, by the sacred name of our great god, Theuth, that I will make new knowledge. New truths will I bring to light, and then, then will no one dare to scorn me.

ACT 1.
Scene 2.
GREEK SCHOOL.

Characters: *Thales, Plato, Socrates, Euclid, and other scholars, Geometry, Algebra, Messenger.*

Thales. (*He is looking out over the sea from under his hand*). Methinks my eyes perceive a noble galleon approaching from

out the mist of distance. Look thou, also, Socrates. Is it not the "Thalanus"?

Socrates. Though it is vague in outline, it must be thy vessel, O master.

Plato. The ship-benches are all full. When does the "Pharaoh" leave?

Thales. Tonight at sundown, does it not, Euclid?

Euclid. So it stands in our tables. But how soon will the "Thalanus" glide to shore?

Thales. We must know immediately. Get thou the instruments, Socrates. I have taught thee, before, how to get the distance of a ship from the land by means of similar triangles. Go, then, Plato and Socrates, and measure thy distances, and show how much ye profit by my teachings.

(*Socrates and Plato go out.*)

(*Enter a Messenger from the Temple.*)

Messenger. Hark ye, O great scholars. I bring ye a message from the priests of the temple. (*Reads from scroll.*) "It is willed by the powerful god Apollo that we double the size of his cubic altar before the sun sets tonight. We are overshadowed by the cloud of his displeasure, and if we fail to accomplish the task as commanded, this horrible plague which is upon us will be doubled in fury—a red fire of vengeance to wreak the will of the heavens. Lend thy wisdom, then, O learned masters. The curse of the gods rests upon us."

Thales. Tell thy lords the priests that all the wisdom of the greatest scholars shall be put to the task of lifting this curse. (*Messenger goes out.*)

Euclid. I will go to measure the altar. (*Exit.*)

(*Enter Socrates and Plato.*)

Thales. We have a message from the temple. (*He hands it to them.*) Euclid has gone to measure the altar.

(*All stand in suspense.*)

(*Euclid returns.*)

Euclid. The altar is a cube, two cubits on a side.

Thales. I think our problem is simple. We shall only have to double the side. Let us make a miniature model.

(*They use small cubes in their model.*)

Euclid. Let us say each cube is two cubits on a side. (*He makes a cube four cubits on a side.*)

Thales. This cannot be right, for this cube is four times the size of the altar.

(*Enter Geometry.*)

Euclid. Welcome, Geometry. Have you heard of the will of Apollo?

Geometry. The anxious voices of the people have carried it to me, and I come to solve your problem.

Thales. Your presence is most welcome, Geometry, for we, alone, are helpless. Here are the models.

Geometry. This problem is simple. (*He places two cubes together.*)

Socrates. But that is not a cube.

(*They all manipulate the cubes to no avail.*)

(*Enter Algebra.*)

Thales. Welcome, Algebra. Can you solve the problem required by Apollo?

Algebra. I cannot. (*She explains as follows.*) The volume of the new altar must be twice the original volume of Apollo's altar. This is what?

Euclid. Since the volume is now eight cubic units, the new volume must be sixteen cubic units.

Algebra. Since sixteen cubic units must be the volume of the new altar, one of its sides would have to be the cube root of 16, which is $2\sqrt[3]{2}$. As you well know, we have no way of finding such a number.

Messenger. (*Enters hastily.*) The sun doth shield his rays. The priests send for the solution of the problem.

The Scholars. (*Looking helplessly at Algebra.*) We are unable.

All. (*Rushing out.*) The plague! The plague!

(*Algebra flees in one direction; Geometry and the others in the opposite direction.*)

ACT 2.

Scene 1.

German Class.

(This scene was copied from Young's *Mathematics in Prussia.*)

Characters: Teacher, and pupils.

$$\frac{x}{2} - \frac{x}{3} + \frac{x}{4} - \frac{x}{6} + \frac{x}{8} + \frac{x}{12} = 11.$$

(*All write problem from book, one reading aloud as he writes and adding: "We seek first the common denominator."*)

Teacher. How do we do that? By a rule?

John. No, by inspection.

Teacher. Right. What is the common denominator?

John. 24.

Teacher. Right. What do we do next, Heinrich?

Heinrich. We multiply both members by 24.

Teacher. What is the result, Wilhelm?

Wilhelm. (*Reading as all write.*) $12x - 8x + 6x - 4x + 3x + 2x = 264$.

Teacher. What do we do next, Karl?

Karl. We unite the terms in the left member.

Teacher. Give the result, Fritz.

Fritz. (*All write as Fritz reads and writes.*) $11x = 264$.

Teacher. What do we do next, Peter?

Peter. We divide both sides by **11**.

Teacher. What is the result?

Peter. (*Reads and all write.*) $x = 24$.

Teacher. We will now work another equation.

(*Original from this point on.*)

(*One of the pupils raises his hand.*)

Teacher. Karl.

Karl. We could make equations from what we learned about triangles the other day. I made one about the sum of the angles of a triangle. Couldn't we work it now?

Teacher. We do not work geometry in an algebra class. That is for the hour on Thursday and Friday only.

(*The class proceeds to work the problem dictated.*)

ACT 2.

Scene 2.

OFFICE OF PROFESSOR MYERS IN THE UNIVERSITY OF CHICAGO.

Characters: *Prof. Myers, Mr. Breslich, Geometry, Algebra, and a class of boys and girls.*

(*Enter Breslich and Myers.*)

Myers. It is a privilege to attend such a meeting. What do you think of the proposed change, Breslich?

Breslich. I think as all intelligent persons must. The adoption of this brings us nearer the Utopia of Education when each student will have an opportunity to study what he desires in our courses in the University. Time will change anything, Prof. Myers.

Myers. Yes, change anything. Isn't it amazing to think over the struggles and the obstinacy occasioned by the application of psychological principles to pedagogy. Yes, remarkable! Think of the new subjects introduced, the new methods employed and the general onward progress even against the most vigorous opposition. I have been dreaming of another great change which I am hoping may be introduced into our department of mathematics. It would mean much to our young people. (*He looks at Breslich questioningly.*)

Breslich. You know, I, for one, may be counted upon to further any plans for advancement. How may I be of assistance?

Myers. Here is our University High School; we have both

algebra and geometry; but it is my impression that each of these branches of the great science of mathematics carries on its work as though ignorant of the presence of the other. If these two could be brought together, they would aid each other immeasurably! (*He gets up and paces excitedly.*) Can't you see what the union of these two subjects would mean to education?

Breslich. (*Nodding.*) Yes, it is an admirable idea. I assure you that I shall thoughtfully consider your suggestion. Goodday.

Myers. (*Musing, not seeming to know that Breslich has left. After a slight pause, there is a knock at the door.*) Come in. Ah, it is you, Geometry.

Geometry. Yes. I have come to ask your opinion of my worth. My uselessness presses upon me. Humanity has a need which I have been unable to supply.

Myers. I have been planning something for you, Geometry. I know that your heart is in your work, so I am going to confide in you. The plan is this: I am confident that the results of your efforts would be more satisfactory if you should join forces with another of our workers, who has practically the same interests as yourself—

Geometry. (*Interrupting.*) I am afraid not. I am quite sure that I could not be a congenial coworker with anyone—that is, except—

Myers. (*Prompting.*) —except?

Geometry. It is a long story, but quickly told. It was on the sands of Greece long ages ago, that we—I and the other—then but infant sciences, played on the sands; the wise men and scholars of the country looked on, some scorned, some encouraged us. But those were happy days when we were together; what we did was childish, but done with joy and hope in the work. Our aim was to lead men to a true knowledge of science. This companionship was ruthlessly ended, and we were separated by the witless interference of man, doomed never to meet again through the long ages which have passed. I have striven to do my work well; my companion likewise, I am sure. But we cannot do, for these generations, what we could do if we were working together. It grieves me to displease you, but it would be impossible for me to work in harmony with any but my true companion.

Myers. And by what name was your companion known?

Geometry. Algebra.

Myers. (*Starting.*) Is it possible—

(*He turns and presses a bell. He tells the stenographer who enters to summon some one.*)

(*He seats himself, and a short, strained silence ensues.*)

(*Then comes a knock at the door. Algebra enters.*)

Algebra. You sent for me?

Myers. Though you have been working in the same school for so many years, I feel sure you have not as yet realized the existence of one, who, though working near you, has never here crossed your path. As I am confident you would make inseparable and invaluable coworkers in your science, I am taking this opportunity to reunite you.

Algebra. (*Interrupting.*) But—

Myers. One moment, please. (*He walks over to Geometry, who, lost in thought, has not observed what has just passed. Myers lays his hand on his shoulder.*) Behold your future comrade: the long-lost companion of your youth.

(*Algebra and Geometry start on recognition, and Geometry reverently kisses the hand of Algebra.*)

Myers. My dream will be realized! Algebra and Geometry, brother and sister sciences, united at last, and my ideal of correlation reached!

(*Breslich enters, excitedly.*)

Breslich. I felt that your thoughts must be taking shape. Ah, it has come. Algebra and Geometry united! What a future I see for them!

Myers. Yes, yes. The help they will give each other is immeasurable! Their friendship and natural need for each other will draw the learners closer in their work. Another change, another step in advance. It has been realized here, and soon will have entered into the educational systems of all countries.

Breslich. Ah, I am even now planning a text for the guidance of students. Let me talk of it with you. (*They stand as though discussing this, and a modern lesson in first year correlated mathematics is revealed to the side, as though an embodiment of their thoughts.*)

MODEL LESSON.

Teacher. What were we studying yesterday, Mary?

Mary. Triangles.

Teacher. What do we know about triangles?

Jane. A triangle is a figure having three sides and three angles.

Teacher. Into what two classes may the angles of any triangle be divided, William?

William. Into interior and exterior angles. The interior

angles are those inside the triangle, and the exterior angles are those formed by extending the sides of the triangle.

Teacher. Very good. What did we learn about one of the classes of angles yesterday?

Henry. We discovered that the sum of the interior angles of any triangle equals a straight angle, or 180°.

William. Well, will the sum of the exterior angles of a triangle equal 180°?

Teacher. Good question. We'll find out. We shall need a figure for that. John, will you please draw a figure and name the parts?

Teacher. What are some of the things that we know which may help us out, Louise?

Louise. We know yesterday's problem.

Teacher. Write it on the board in terms of the angles.

(*Louise steps to board, and writes:* $x+y+z=180°$).

Teacher. What else do we know?

(*Silence for a moment, and then one raises her hand.*)

Mary. We know that $x + w = 180°$ because they form a straight angle.

John. Well, then $z + t = 180°$ and $s + y = 180°$ for the same reason.

Teacher. Write it on the board. (*John writes these facts upon the board.*)

John. We can make another equation by adding our letters and degrees.

Teacher. Do it. (*John goes to board and writes* $x + y + z + w + t + s = 540°$.) Now, what shall we do? Is it of any use to have two equations instead of one?

Jane. We can add the two equations.

Pupils. (*Chorus of "No."*)

John. We should subtract, because then we will have just the exterior angles left, and that is what we are working for.

Teacher. Do you all agree?

Pupils. Yes.

Teacher. Do this step for us, Jane.

(*Jane goes to board and does subtraction.*)

Jane. Then that leaves $w + s + t$, the sum of the exterior angles.

Teacher. What does the sum of these exteriora ngles prove to be?

Pupils. *360°*.

Mary. Geometry is just like algebra, isn't it?

John. I can do it another way. (*By paper folding he puts the angles together and makes a circle.*) The sum of the exterior angles of a triangle is equal to 360°.

GRADING PAPERS IN GEOMETRY.

By Nelson A. Jackson,
Friends' Academy, Locust Valley, N. Y.

One paper is marked 83 and another 86. This difference of three points may be an all important matter to some pupil. What do these grades mean? Can the teacher say, with any certainty, that one paper is exactly 3/100 of the whole better than the other? A teacher would hardly be willing to go on record with any stronger assertion than that, in his judgment, the first paper was slightly better than the second. Suppose another teacher had graded these papers, would the results have been the same? Werremeyer and Starch have tested this point and their results show that there is absolutely no uniformity among mathematics teachers in marking papers.

Dr. Werremeyer gave five test papers to six teachers; for the first paper, grades ranged form 63 to 95; for the second, 79 to 90; for the third, 61 to 74; for the fourth, 55 to 96; for the fifth, 86 to 95. "No one teacher estimated all the papers low and no one teacher estimated all the papers high. That is, no teacher had an exceptionally low standard or an exceptionally high standard."

Starch had 138 teachers grade the same paper in geometry; the resulting ranks varied from 25 to 90. Five teachers in the same school, where uniformity might be expected, gave grades ranging from 59 to 70. One answer graded by forty-nine teachers on a scale of 0-12½ was marked 0 by nine; 5 by ten; and 12½ by one; the other grades ranged between these limits. In drawing conclusions from these results, Starch says, "It is, therefore, fully evident that there is no inherent reason why a mathematical paper should be capable of more precise evaluation than any other kind of paper. In fact, the greater certainty of correctness or incorrectness of a mathematical demonstration or definition may even contribute slightly to the wider variability of the marks, because the strict marker would have less occasion to give the pupil the benefit of the doubt.

For the past thirteen years, the writer has been sending geometry papers to the New York State Regents for review. Frequently, marks have been changed on the papers sent; at times, the grades have been raised from three to ten points and in some instances they have been lowered. In two instances, there has been a radical difference in marks; one rank of 67 was lowered to 38 and another from 80 to 55. In both cases,

there was a principle involved, which I will discuss later in this paper.

What does a grade placed on a Geometry paper represent? Does it show the exact value of the written work put down on paper? Theoretically, this has been the time-honored idea of ranks. If this were correct, one hundred teachers should grade the paper approximately the same. At present, many elements go to make up the grade given. Neatness, arrangement of work, the length of proof, reasons used, completeness of proof, effort put forth by pupil, teacher's feeling toward pupil, and comprehension of fundamentals are a few of the things which, consciously or unconsciously, influence the teacher in marking the grade. Will the same rank be given to a lazy pupil as to an industrious one, provided the work done on the paper is practically the same in amount and character? Of course the personal element does not enter when the papers are examined by one other than the teacher. A teacher should not be influenced by attitude when grading a paper. Can a teacher be absolutely impersonal in ranking papers from his own class? Most teachers try to be. Some make a practice of not looking at the name of the pupil until the grade is given.

Our present system of marking is little better than none. Colvin says: "In reality, there has never been a marking system, but rather a marking practice, that has never been systematic." Our present practice does not result in fairness to our pupils. Meyer says, "If there is no uniformity of grading in an institution, this means directly that values are stolen from some and presented undeservedly to others."

The Regents of the State of New York send out the following directions, which are valuable and tend to secure some kind of uniformity in grading.

1. In rating answers to questions that call for the reproduction of definitions, principles, fundamental demonstrations, and examples that are mechanical and that illustrate the application of these principles, the examiner should be severe; for instance, a definition partly wrong should be granted no credit.

2. In rating answers to questions that call for the application of principles and definitions, when the relations involved are expressly stated, such as finding the contents of a room, having given the length, breadth and height, less than 60 per cent of the credit should be granted when an error in computation occurs; still less credit should be granted when more than one error occurs.

3. In rating answers to questions that call for the solution of problems or of originals, when some of the relations are not explicitly stated, that is, questions that test the pupil's ability to apply mathematical principles when the relations are implicit rather than explicit, the examiner should be more liberal than when rating answers mentioned in suggestions 1 and 2.

4. No credit should be granted for the solution of numerical problems unless all necessary operations (except mental ones) are given. No credit should be granted for figures.

5. In all answers in which the omission of a step would destroy the logical sequence of the solution, every step should be given, even though some steps might be regarded as mental processes.

6. When proofs are called for, no credit should be granted for simple numerical illustrations of principles. Proofs of special cases should ordinarily receive no credit—never more than 50 per cent.

7. In the demonstration of theorems in geometry, (one-fifth of the assigned credits should be granted for the correct drawing of the figure with all auxiliary lines and the statement of the hypothesis with relation to the figure; four-fifths of the credit should be allowed for the demonstration.) The reasons should be given for every step in the demonstration. In the revised directions just issued the part included in the parentheses is omitted, with the following added. "Rate the proof as a whole. One erroneous reason may invalidate the whole proof."

8. In construction problems when proof is called for, three-fifths of the assigned credits should be granted for the correct construction of the figure and two-fifths of the credits for the proof.

9. Proofs in which "reasoning in a circle" occurs, should be carefully scrutinized. If the sequence is impossible, or the inability of the pupil to prove the sequence is evident, no credit should be given. The test of the validity of a reason is whether or not the reason given depends for its truth upon the statement which is being proved and not whether or not the reason occurs later in the textbook.

10. In answers involving the solving of problems by the use of formulas, not more than 2 credits should be granted for merely the writing of each formula.

Some idea of the success of these standards is given by the fact that in 1913, 13.6 per cent of the geometry papers submitted by New York State teachers were rejected by the Regents' examiners; in 1912, 17.2 per cent; in 1911, 14.7 per cent.

Statement No. 7 in the above directions indicates that in the demonstration of theorems, little or no credit should be given unless the whole is perfect. In marking the demonstration, should any credit be given if partially correct? A difference of opinion concerning this question was the reason for the difference of 29 and 25 points respectively, in the grading of the two papers mentioned above.

To illustrate: In demonstrating a theorem, the proof of which required eleven steps, the pupil gave an incorrect reason for the third step and omitted the reason for the fourth; both of which reasons were important. The balance of the proof was correct. The correct answer was worth 14 points. The Regents' examiner graded the answer given as worth 4 points. That, according to No. 7 in their directions, would allow only 1 1/5 points for the proof, as the construction and statement of hypothesis were correct. A vigorous protest was made and the paper returned for reexamination. It came back with the accompanying statement made by Harlan H. Horner, Chief of Examina-

tions Division, in part as follows: "It is entirely impossible to divide a proof in geometry into steps and assign credit to each step. A proof is valueless, unless the steps in it are correct." With this statement, the writer does not agree. The pupil should have credit for knowledge exhibited by his written work. If a child makes a chair in manual training and omits a few pins, so that the chair, when used, falls to pieces, the whole is not condemned, but he is given credit for the ability and skill to plan his chair, make the joints and put the pieces together. The demonstration above mentioned should have received, at least, 10 of the 14 points.

According to No. 4, no credit is to be given the pupil who interprets problems graphically and then shows the conditions. Such figures are often a great aid in the numerical solution of a problem and should usually receive at least 10 per cent credit in a given answer.

Neatness and accuracy are two of the aims in geometry. The slovenly paper, with careless, inaccurate drawings should lose, on that account, at least 5 points for appearance.

On account of the impossibility of close grading, there is some advantage in the letter system of marking papers.

The writer would suggest the following standards as guides in grading papers on a scale of 100.

1. Definitions, axioms, postulates and theorems should receive no credit, unless correct.
2. In rating demonstrations, 10 per cent should be given for a correct figure; 10 per cent for correct statement of hypothesis; 80 per cent for the proof. Correct steps should receive some credit, although the entire proof is not correct.
3. In construction problems, 50 per cent of credit should be given for the correct construction with all construction lines and 50 per cent credit for a correct proof (when required).
4. Numerical problems involving the application of theorems should be rated 40 per cent for method and 60 per cent for computation.
5. Original exercises which need demonstrating, should be rated as indicated in No. 2.
6. From 5 per cent to 10 per cent should be marked off from papers on which the work is slovenly and figures carelessly and inaccurately drawn.
7. Numerical illustrations in place of proof should receive no credit.
8. Special cases and "reasoning in a circle" should ordinarily receive no credit.
9. Any indication of originality should be liberally rewarded.

The above set of directions for grading papers is not sufficiently explicit nor binding to cause uniformity. Is it possible to work out standards of reference so that there will be any degree of uniformity?

Standards of reference have been worked out for measuring mathematical abilities, but at present the mathematics of sta-

tistics is so little known by the rank and file of geometry teachers that these standards are intelligible to few others than specialists.

The Missouri plan outlined by Meyer is comparatively simple, but not feasible for small classes. The standard worked out by Prof. Pearson is too complicated for universal use. Uniformity is desired and teachers will welcome a standard of reference which is suitable for universal adoption.

At present, it is the duty of every teacher to make a conscientious study of marking. If no directions for marking are furnished, let each teacher formulate his own and hold himself to them in marking his papers. Let him try to keep his own marks uniform. It is our duty to make the best use of our present tools and at the same time strive for new tools.

MATHEMATICS ASSOCIATION IN NORTH CAROLINA.

North Carolina has effected an organization of the teachers of secondary mathematics for the western portion of the state. The following officers have the work in hand: W. W. Rankin of the University of North Carolina, president; J. W. Moore of the Winston-Salem High School, first vice-president; Miss Fannie Starr Mitchell, of the Raleigh High School, second vice-president; L. R. Johnston of Oak Ridge Institute, third vice-president; J. W. Lasley, jr., of the University of North Carolina, secretary-treasurer.

This organization is the outgrowth of the feeling that the conditions in the secondary schools and colleges of the state would be bettered by the cooperation of the teachers. At the first meeting, held in Greensboro, April 13th and 14th, the situation was gone over with care and plans laid which have as their aim better teaching of mathematics in North Carolina.

A Plot Was On Foot

AGRICULTURAL BOTANY.[1]

By Worralo Whitney.
Hyde Park High School, Chicago.

Many who are interested in the biological subjects in the high schools believe that the teaching of these subjects has fallen into a condition of stagnation in the average school. It is true that here and there a teacher has the courage and energy to strike out on a path for himself, but as a rule teachers of biology seem to be content to follow a certain routine, made easy because others do this and because they were taught along this line in college. We have been condemned by students of education, and the spectacle of the rapid adoption of courses in agriculture, often supplanting the biological courses upon which agriculture is founded, ought to convince the most zealous advocate of the prevalent courses in botany and zoology that these subjects as now usually taught are not convincing people outside our circle of their worth.

What can be done about this condition of stagnation into which we have fallen? Some have cast the old course aside and substituted new courses in its place. But there is danger in this, danger that the substituted course will not be well thought out. Rather that it will be spotted and superficial, for it is easy to go astray in this direction. I am conservative enough to believe that we have a real science and that it is our mission as teachers to give some conception of the fundamentals of this science in our courses, no matter how far apart they may be in other ways. The course, then, must be carefully organized, but not slavish to any conception of logical evolutionary order. Perhaps it will be helpful to consider at this point the principles which should underlie the construction of a course in botany.

The principles governing the selection of topics are quickly stated. Those of major importance are: 1. The course must contain the fundamental facts and principles of the science which are within the ability of the pupil to understand and without which the course is superficial. 2. So far as there is a choice, choose topics that relate themselves to the lives of the pupils and explain familiar phenomena. 3. Choose some topics that have a special appeal to the pupils and will arouse interest and enthusiasm. 4. The arrangement of the topics should be seasonal as far as practical.

[1]Adapted from papers read before the Biology Sections of the Wisconsin State Teachers Association, Milwaukee, Nov. 2, 1916, and the High School Teachers' Conference of the University of Illinois, Urbana, Nov. 24, 1916.

Some factors of minor importance which must be considered concern the adaptation of the course to the locality, the school, and the teacher. These may be enumerated as: 1. The surroundings of the school, including opportunities for field work, collection of suitable material for study. Home opportunities such as gardens, farms, and yards. 2. The equipment of the laboratory. This equipment need not be expensive, but among the most important are a set of carpenter's tools, a work bench, and cases for storing and display of collections. 3. The teacher himself, his limitations and resources, are very important. The teacher should have such command of his subject as will enable him to adapt the course of study to himself, his pupils, his equipment, and his school surroundings in such a way as to get the most profitable results. No course should be taken from outside sources and followed slavishly.

Of these factors, both major and minor, which I have enumerated as important in constructing a course of study, only one needs further elaboration. Some will ask what these fundamentals are which must be found in every course in botany. shall attempt to state them briefly as I now see them, and it is here we shall disagree if at all. In my opinion, based upon my own experience and study, the fundamentals which should be found in every course, measured by the results to the pupils, are: 1. Ability to recognize the more common plants which are met in everyday life, and some knowledge of their habits. 2. A knowledge of the gross structure of cell, tissue and organ and their relation to the plant body. 3. A knowledge of the simplest forms of reproduction in the algae and the large details of the pollination and fertilization in spermatophytes. 4. An elementary knowledge of the advance from simple to complex in plants as seen for example in the algae, and a similar knowledge of the competition and struggle for existence among plants as for example among weeds in waste fields or vacant lots. 5. A working knowledge of the most important of the fundamental processes of plant life, such as photosynthesis, transportation of foods and water, etc.

It will be noticed that two common topics found in practically all textbooks of botany are not included in this list of fundamentals. They are the evolution of the plant kingdom from one group to another, and alternation of generations. These two topics are the ones which have bound us to a certain course and made much variation practically impossible. The evolution of

groups involved a series that must occupy the major part of any course if taught in a manner to be of any value at all. And as a matter of fact the value derived by the pupil is usually nil. Just what advantages its elimination from the course gives will be better seen in a course of study which I shall discuss later.

The five topics I have classified as fundamental need no discussion in this statement, for all agree on their desirability, but all may not agree, however, in their application in the course of study. The first topic requiring acquaintance with common plants, while generally acknowledged as important, usually receives such a scant allowance of time that it is of little real value. I have called this work neighborhood botany. In my course it includes some study of trees, shrubs, decorative planting, weeds of waste fields and vacant lots, winter conditions, and the more common wild flowers of fields and woods. While city pupils are less familiar with these plant surroundings as a rule than country students, the familiarity of the country boy and girl is not much more than knowledge of them as objects seen round about them. Judging from my own boyhood experiences on a farm with a father and mother who were lovers of plants, the knowledge the country boy has of his plant surroundings is superficial and of little scientific value. For these reasons I place a knowledge of the plant world and phenomena with which the average boy or girl comes in contact as of first importance. It would be just as logical to say that in physiology the pupil need not study the skin, eyes, ears, and teeth, because they are familiar objects.

It will be seen that my appeal is not, strictly speaking, an appeal for the study of the botany of agriculture, but something broader. It is the plea for emancipation from some things we have been doing which have made our work dull and uninspiring to the average tenth grade pupil. It is a plea for more that is of human interest to the boys and girls in our classes, more that tends to inspire enthusiasm. If we teach the right kind of botany in the right way our pupils gain a love of plants and a desire to know them that will never leave them.

I might stop here with the abstract discussion of our needs, for it is where the usual paper does stop, but I will not, though I am well aware that the minute we proceed to the concrete applications we begin to hit some one's pet topic and are liable to stir up a hornets' nest of protest. But if in presenting a course of study in accordance with the views expressed in this paper I invite criticism and argument, I will have done good. It is

stagnation that does harm. It must be remembered that every course in botany must, if it is to be alive to the pupils, be adapted to the needs of the particular situation, whether it be country, village, town, or city, the school of 100 or 2,500 pupils. So the following course must not be taken as laying down hard and fast topics which may not be modified, but rather as a suggestion of what may be done. Agriculture has been made the central idea of the human interest side of the work because of its importance to all, city and country alike, and because of the crying need of showing that biology is fundamental to agriculture.

The outline of whole year and half year courses which I am presenting must for lack of time be very meager in details. It may be said in general that the order of topics is determined so far as practicable by the season. Very little preserved material should be used in a high school botanical laboratory. The material should so far as possible be abundant and fresh. The amount of laboratory work is not to be designated, but all the topics in the outlines should be studied in the laboratory for the foundation of facts and training in observation and inference. These facts thus acquired should then be confirmed, amplified, and built up into a consistent orderly body of knowledge through recitation and textbook.

Some may be misled by the title of my paper into expecting agriculture to be dominant throughout the proposed course. But such persons must remember that agriculture is an applied science, while botany is a pure science. The course as planned is intended to lay the foundations for the applications of agriculture. It is not intended to take the place of a course in agriculture, but rather to prepare the ground for such courses, if these courses are given. Where no agriculture is given it will pave the way to rational thinking concerning agriculture and its problems. For the sake of stimulating interest and enthusiasm, some topics, such as seed testing, perhaps more agricultural than botanical, have been introduced. They add a very lively interest to the work and are fully justified from this point of view alone.

May I repeat what I said earlier in this paper, that in offering this course of study I am not calling it a finished product. It is suggestive and explanatory of the principles sought to be emphasized in this paper.

One Year Course in Agricultural Botany.

Autumn Semester.

1. *General Outline:* Variety of plants—in size, form, manner of growth, number in a given area; the gross parts of a plant.
2. *Light Relations of Plants:* Arrangements of leaves, their response to light, why light is important (experiments to show this).
3. *Autumn Flowers:* In general—their size, numbers, colors, etc.; in particular—the flower type: polypetalous, sympetalous, composite; pollination.
4. *Trees and Shrubs:* Characteristics of the more common trees and shrubs—how to identify them; their good and bad qualities; care needed.
5. *Decorative Planting:* Rules governing the arrangement and kinds of trees, shrubs, perennials, etc., to plant; their care; the lawn; planning a home yard.
6. *Weeds:* Weeds as successful plants, their characteristics making for success, their harmfulness, their avoidance, their abundance.
7. *Seeds and Fruits:* Types of seeds and fruits and their methods of dissemination.
8. *Competition:* Using weeds as a basis, bring out struggle for existence with factors of foothold and food; distribution of plants by areas limited by soil, moisture, etc.; plant associations.
9. *Soil Studies:* Mineral constituents, origin of mineral and humus constituents, types of soil, drainage, tillage, fertilizers, rotation of crops.
10. *The Cell:* Its structure and relation to other cells; cell products—starch, chloroplasts.
11. *Algae:* Increase of complexity of plant body—cell, chain, filament, plate, etc. Types of reproduction—division, conjugation, sexual. Nutrition of the cell.
12. *Fungi:* As dependent plants in their relation to disease and sanitation. Molds, parasitic fungi, yeast, bacteria. The spore in reproduction.

Spring Semester.

1. *Winter Conditions:* Protective arrangements of trees, herbaceous perennials, annuals. Readiness for growth. Dormancy.
2. *Seeds and Seedlings:* Seeds as dormant plants, germination, types of seedlings.

3. *Foods of Plants:* Kinds, storage purposes, value to seedlings and to man.
4. *Seed Testing and Judging:* Test germination of corn seed. Rules and practice in judging corn. Vitality of seeds; value of tests.
5. *Plant Breeding:* Variations in wheat heads and corn ears, variation in plants, breeding by selection, hybridization, sports and mutations, laws of heredity.
6. *Garden Planning:* Plans, successions, hotbeds and cold frames, care.
7. *Roots as Absorbing Organs:* Root hairs and their work; types of roots in relation to absorption.
8. *Structure and Work of Root, Stem and Leaves:* As organs of transportation, support, and food manufacture.
9. *Economic Uses of Root, Stem and Leaf:* Food storage, wood structure, types of woods, commercial uses.
10. *Propagation:* Natural and artificial methods of producing new plants by vegetative reproduction.
11. *The Flower:* Parts and function of a flower. Types of flowering plants—gymnosperm, monocotyl (including a cereal), dicotyl.
12. *Wild Flowers:* Their succession, distribution, regional habit. Use of simple key.

Half Year Course in Agricultural Botany.

Spring Semester.

1. *The Plant a Living Thing:* The cell, tissues, organs, types of reproduction—using onion skin, elodea leaf, algae, and a flower. The work of a plant as a living thing—respiration, transpiration, and photosynthesis.
2. *Winter Conditions of Plants:* Protective arrangement of trees, herbaceous perennials, annuals. Dormant conditions. Readiness for quick growth in spring.
3. *Seeds and Seedlings:* Seeds as dormant plants. Germination. Types of seedlings.
4. *Food Storage in Seeds:* Tests of foods in seeds. Use of storage to the seedling, digestion of food.
5. *Seed Testing and Judging:* Tests of germination of corn. Vitality of seeds. Judging seed corn.
6. *Roots as Organs of Absorption:* Study of root hairs and their function. Osmosis. Other arrangements of roots for absorption.
7. *The Work of Roots, Stems and Leaves:* Larger details of

structure to be studied sufficient for understanding the functions. Demonstrations of functions.

8. *Economic Relations of Plants:* Useful—food storage and its uses, structure and types of woods and their uses to plants and man, useful fungi. Harmful—parasitic fungi and bacteria in relation to diseases of plants and man and to sanitation. Weeds.
9. *The Soil:* Origin of soil, mineral and organic constituents, drainage, tillage, fertilizers, rotation of crops.
10. *Gardening and Decorative Planting:* Garden planning. Beautifying the home surroundings. Characteristics of common trees and shrubs.
11. *The Flower and Wild Flowers:* Types of flowers, including dicotyls and monocotyls. Wild flowers and their regional distribution. Plant associations.
12. *Plant Breeding:* Study of variation in some plant as, for example, wheat. Breeding by selection and hybridization. Sports and mutations. Laws of heredity.

CIRCULAR OF A CENTURY AGO.

A Philadelphia firm of type founders has issued the following circular calling attention to the importance of the development by the United States of domestic supplies of essential metals:

"The present state of the commerce of the United States, arising out of the conduct of the belligerent powers, having shown our wants, and pointed out the necessity of calling to our aid such of the natural productions of the country as our knowledge and research might enable us to discover, with a view to this important object, we particularly solicit your attention to the article of antimony, which is essential in the manufacture of printing types, and which has not hitherto been discovered in this country. Bismuth would also be a great acquisition, and profitable to the owner of the mine. As it is highly probable that articles which abound in so many parts of Europe are not totally wanting in this extensive country, we earnestly request you to make the necessary inquiries in your neighborhood, and, should you discover anything which promises a favorable result, to transmit an account of it to us.

"We are, respectfully, "BINNEY & RONALDSON,
"*Letter Founders.*"

The only comment to be made on this statement is that the date of the circular is February 17, 1809, at which time the sole method of calling attention to the needs of the country in such matters was by personal circular and pamphlet; there was, for instance, no government clearing house of information with reference to minerals, such as the United States Geological Survey of the Department of the Interior.

This circular was found by one of the geologists of the Geological Survey among some of the papers of Thomas Jefferson. Both in tone and substance, this "preparedness" suggestion relating to the development of the country's natural resources is not essentially different from appeals made more than a century later.

BIOLOGY AS A PRACTICAL SCIENCE.[1]

By John M. Coulter.

It is not my purpose to discuss the various ways in which some knowledge of biology may be useful. No one questions that intelligent human beings should have some acquaintance with the structures and functions involved in living and in reproduction. Not only that, but such an acquaintance should be regarded as more fundamental than a knowledge of our material surroundings, which after all need to be understood only so far as they contribute to living and reproduction. In this presence I might venture a step further and suggest as a possibility that some knowledge of biology is of more practical importance than the results of that time-honored educational cudgel, mathematics. Attractive as such a thesis might be, however, teachers of biology need no instruction as to the contacts of their subject with life in a practical way.

At this time, however, I am concerned with the *reputation* of biology as a practical subject. My attention has been drawn to this situation in two ways:

1. The evidence is increasing that such subjects as chemistry and physics are regarded as of far more practical importance than biology. In the colleges and universities with which I am acquainted, an increasing number of students of a practical turn of mind are attracted to the physical sciences, because such training is understood to connect them definitely with practical activities of various kinds. These sciences are to be congratulated upon having established this connection in such a way that the general public can see it. This has not been accomplished by slighting the fundamentals, but by showing that the fundamentals must underlie all rational practice. The feeling is growing, and bids fair to become dominant, that education must connect directly with activities. We may differ in our judgment as to whether this is wholly desirable or not, but we must reckon with it as a fact. As a result, biology is in danger of being regarded by the general public, and by students who simply record public opinion, as the least practical of the sciences.

2. My attention has also been directed to this subject by the recent organization of the National Research Council, appointed by the National Academy of Science at the request of President Wilson. The purpose of this Council is to bring into cooperation

[1]Read before the Biology Round Table of the Kansas State Teachers' Association, Nov. 10, 1916.

all of those scientific and practical activities which have to do with national welfare. It is an attempt to coordinate the intellectual resources of the country, so that they may be stimulated and may be available. In other words, it is that phase of national preparedness which science and its applications can supply if properly coordinated and directed. The National Academy knew enough to include a biologist as a member of this Council, but I have been asked more than once what a biologist has to do with national welfare. This means that this movement, expressed by organization of the National Research Council, may still further emphasize the feeling that biology is not a practical science, that is, a science of human interest, unless the teachers of biology do something to counteract it.

In view of the situation thus outlined, my claim is that the time has come to correct this public impression in reference to biology, and it can be done by teachers of the subject beginning with the high school and continuing on through the university. This does not mean a revolution in the teaching of biology. We must continue to teach the fundamental facts as we are doing now, but we must not allow these facts to remain in cold isolation, entirely unrelated to the activities of life. This does not mean that we shall add to our teaching of fundamental biology an attempt to carry it into practice. For example, it does not mean that teachers of botany shall also teach the practice of agriculture, nor that teachers of zoology shall also teach the practice of stock breeding. These two functions must be kept distinct. To combine them is to introduce confusion, resulting in no clear apprehension of the fundamentals, or of their application.

It does mean, however, that every teacher of biology in connection with his teaching the fundamentals, should also develop a perspective of the practical aspects of his subject, the points of contact it has with human welfare. It is not teaching a *practice*, but developing a *vision*. In my own experience I have found that students, while working upon the purely scientific aspects of plants, respond in what seems like gratified surprise to suggestions that all this underlies a possibility of a much more effective handling of plants in supplying human needs.

I wish now to analyze the situation, that we may have it before us clearly, and to outline the perspective that may change it and rehabilitate biology in public estimation as the most important of all the sciences to human welfare. In short, I am asking you

to cooperate in arousing the public to a realization of the fact that biology may be made one of the greatest assets of a nation.

We should realize first how the present condition of scholarly isolation has arisen. Men who spend their lives in colleges and universities, especially the older ones, are apt to develop certain unfortunate peculiarities. These peculiarities may not make them less happy or less useful to their professional students, but they diminish the appreciation of the community at large. In the life of such an instructor or investigator, there is a peculiar kind of isolation that is bound to react.

It is partly the isolation of a subject that seems more or less remote from general human interests, at least in the aspects the investigator is cultivating. As a consequence, he feels that his world is quite apart from that one in which the majority of men are living. He is conscious of an interest distinct from their interests, which seem to him therefore relatively trivial. This sense of intellectual aloofness does not result in a feeling of loneliness, but rather in a feeling of superiority, unconscious in many cases, but often naively expressed.

It is also the isolation of authority, which comes from mastery of a subject and association with students who recognize this mastery. To speak with authority in intellectual matters, to give the deciding word, to meet a constant succession of inferiors, is apt to affect any man's outlook on the world of practical affairs. Either he becomes dogmatic in expression, or he must hold himself in check with an effort.

There has been much honest effort to break down this barrier between the scholars who represent universities, and the great host of men who represent the community. These men are not so isolated, but they are just as dogmatic in their own way, and they are immensely influential. Even when the two groups mingle, the scholar is often only a man of incidental interest, who possesses much curious information about many useless things. Here are two groups of men, the scientific and the practical, both powerfully equipped, who should be mutually stimulating in all that makes for progress. Mutual stimulation can follow only after mutual understanding; and this we as teachers can promote.

Men engaged in research are apt to be looked upon in general as inoffensive, but rather curious and useless members of the social order. If an investigator touches now and then upon something that the public regards as useful, he is singled out as a glaring exception. If an investigation leads itself to announce-

ment in exceedingly sensational form, as if it were uncovering deep mysteries, the investigator becomes a marked man, and his lightest utterance is treated as an oracle. In all probability he is called a "wizard." The fact is that the great body of investigators who are doing the substantial work that makes for scientific and practical progress, are unknown to the public. This lack of information the schools should supply.

There has arisen a classification of science into two phases, called *pure* science and *applied* science, which has more to do with the public conception of biology than any single factor. An attempt to define these two kinds of science reveals the fact that the distinction is a general impression rather than a clear statement. If the impression be analyzed, it seems that pure science is of no material service to mankind, and that applied science has to do with the mechanism of our civilization. The distinction therefore is based upon the material output. In other words, pure science only *knows* things, while applied science knows how *to do* things. This impression has been unfortunate in several ways. The public, as represented by the modern American community, believes in *doing* things, and therefore to them pure science seems useless, and its devotees appear as ornamental, rather than as vital members of society, to be admired rather than used.

On the other hand, the universities, as represented by their investigators, believe in *knowing* things, and therefore to them applied science seems to be a waste of investigative energy, and its devotees appear to be very unscientific. In this atmosphere of mutual misunderstanding, the public and the investigators have continued to exist and make progress.

In recent years, however, the spirit of mutual service has come more into evidence, and investigators are beginning to recognize their greatest mission is contributing assistance in solving the problems that confront community life. In some quarters, a university is coming to be recognized, not as a refuge for the intellectually impractical, but as a reservoir of the intellectually competent. This new spirit of mutual service is so attractive and inspiring, appealing to what seem to be our best impulses, that it threatens to become a real danger to the whole scheme of education. The reaction is natural, but its demands must be recognized as representing the initial and extreme recoil stage of a new motive. The new motive must not eliminate all the old motives, but must adjust itself efficiently among them. The demand to

substitute in the schools various forms of applied science for instruction in pure science, always suggests to me a demand to change our electric light systems by retaining the obviously practical electric lights and eliminating the impractical power house.

I wish to indicate the real relation that exists between what has been called pure science and applied science, a relation which shou'd be emphasized repeatedly with students, as a part of our teaching programs. It is information that must reach the public.

As an introductory illustration there may be outlined the usual steps that biological science has taken in the material service of mankind. Numerous concrete illustrations can be used with students. An investigator, stimulated only by what has been called the "delirious, yet divine desire to know," is attracted by a problem. No thought as to its usefulness in a material way is in his mind. He wishes simply to make a contribution to knowledge. The investigator succeeds in solving his problem, and is satisfied. Later, perhaps many years later, some practically inclined scientific man discovers that the results of the former may be used to revolutionize some empirical practice in agriculture or in stock breeding. The application is made and the world applauds, but the applause is largely for the second man, the practical man. An analysis of the situation, however, shows that to the practical result both men contributed, and in that sense both men were of great *material* service.

Another illustration is needed as a corollary. In this case, a practical investigator, stimulated by the desire to serve the community, is attracted by a problem. He succeeds in solving his problem, perhaps makes his own application, and is satisfied. Later, some other scientific man discovers that the results of the former may be used to revolutionize certain fundamental conceptions of science. His statement is made, and the scientific world applauds, and this time the applause is largely for the second man, the pure scientist. The analysis in this case shows, however, that to the *scientific* result both men contributed, and that both men were of large *scientific* service.

A third illustration is needed to complete the real historical picture of progress in scientific knowledge and its practical applications. A practical man, not trained as an investigator, faces the problem of obtaining some new and useful result. His only method is to apply empirically certain formulae that have been developed by science, but with ingenuity and patience he suc-

ceeds, although he is not able to analyze his results; and yet his procedure reveals to a trained investigator a method or certain data that lead to a scientific synthesis of the first order. In this case, a practical man chanced to be of great scientific service.

These illustrations represent the actual historical situation of the mutual influence of botany as a science and agriculture. Now what are the conclusions?

It is evident that responsibility for practical results is to be shared by those engaged in pure science, those engaged in applied science, and those not trained in science at all. The only distinction is not in the result, therefore, but in the intent. In other words, the difference between pure science and applied science in their practical aspects resolves itself into the difference between murder and manslaughter. It lies in the intention. So long as the world gets the practical results of science, it is not likely to trouble itself about the intention.

Another conclusion is that all application must have something to apply, and that application alone would presently result in sterility. There must be perennial contributions to knowledge, with or without mutual useful intent, that application may possess a wide and fertile field for cultivation.

A final conclusion may be that all science is one; that pure science is often immensely practical; that applied science is often very pure science; and that between the two there is no dividing line.

I wish to illustrate these general statements concerning pure science and applied science by a concrete example from my own subject, simply to indicate how we can make the contacts between our pure science and the human welfare.

The science of botany has had a remarkable history. Beginning with the investigation of plants for what were called their medicinal virtues, it developed with various progressions and retrogressions, until the botanist came to be regarded as about the most useless intelligent member of society. His chief concern seemed to remove him so far from the general human interest, that he was regarded as a harmless crank at best, a man of only ephemeral interest. No such opinion could have developed unless there had been some basis for it.

The most unfortunate result was that this public estimation of botany lingered much longer than it was deserved, and consequently, when the other so-called sciences had won public esteem, either through their services or their appeal to the won-

der instinct, botany lagged behind in public recognition, and in most educational institutions was the latest born in the family of sciences; but finally it also began to render signal service and to appeal to the wonder instinct.

This is not the occasion for me to give an account of the wonderful recent developments of several phases of botanical activity, phases which deal with the fundamentals of plant activity of all kinds, and are directly related to plant production. Among them, however, there is no one attracting more attention at this time, both in its scientific and practical aspects, than plant breeding.

It is not my purpose to recite the notable achievements that are grouped under this title, for they are familiar to all who are interested in such subjects. Without going into details, therefore, I simply wish to use plant breeding as a brief illustration of my thesis.

The *practical* aspect of plant breeding, in a certain sense, is as old as the cultivation of plants. Long experience in the practical handling of plants slowly developed the kind of knowledge that became formulated in practice; that is, practice whose meaning was not understood, but whose result experience assured. The general purpose was to improve old forms and to develop new ones. The improvements were numerous, and apparently were possible in any direction determined by the need or taste of man. It was learned that improvements must be kept improved; in other words, that they would not remain constant, if left freely to nature.

During all this period of plant improvement by selection, the so-called science of botany was cultivating a singularly distant field. In short, botany was not practical, and plant breeding was not scientific, therefore, botanists on the one hand, and agriculturists, horticulturists, etc., on the other hand, were as distinct from one another as if they had nothing in common. It so happened that botanists were dealing with very superficial problems in a scientific way, and that plant breeders were dealing with the most fundamental problems in an empirical way.

As in any other practice, plant breeding developed now and then an unusually successful practitioner, who made distinct contributions in the form of important results; but this represented no more of an advance than does the fact that one cook can surpass another cook in the art of making bread.

What may be called the second period of plant breeding was

ushered in when organic evolution began to be put upon an experimental basis. Plant breeding had been practical, but with no scientific basis; now a new plant breeding was established, which was scientific, and with no practical motive. The new motive was the accumulation of data bearing upon the problem of inheritance and the origin of species. As a by-product of this work on inheritance and evolution, some of the scientific results have been applied to practical plant breeding, and the result has been an expansion of its possibilities that may well be called marvelous. In short, practical plant breeding is now on a scientific basis, and botany has at last attacked the fundamental problems and is beginning to be of great practical service.

In presenting this fleeting glimpse of the problems and accomplishments of plant breeding, I have intended to emphasize the inextricable entanglement of pure and applied science. Any result of scientific plant breeding, representing, as it must, additional knowledge of the processes of heredity, may become of practical service; and any result of practical plant breeding, involving, as it does, extensive experiments with plants, may prove to be of great scientific importance. They are mutually stimulating, and both are necessary to the most rapid development of knowledge.

It is the proper balance between the two that must be maintained. The physical needs of man, great as they may be, must never obscure the intellectual needs of man, especially as the trained intellect is the speediest agent in meeting physical need. On the other hand, the intellectual needs of man, noble as they may be, must never lose sight of the fact that the speediest results are often obtained by the enormous mass of experimental work under the pressure of physical necessity.

The motto for our new biological perspective, therefore, which we must impress upon students, is as follows:

A practice based on science, and a science that extends and illuminates practice.

It is to such an educational campaign that I would invite all teachers of biology. Let every student know, in order that the next generation of men and women will realize, that biology is not a detached subject; is not merely a means of training the mind; is not merely a matter of microscopes and dissections; but that it is also the most vital of subjects in its practical service to mankind; and that it is sure to become eventually our most important national asset.

GRAHAM'S LAW OF GASEOUS DIFFUSION.

By William H. Chapin,
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The law of gaseous diffusion is not without great significance, either theoretical or practical, and yet very little is ever made of it in any course in chemistry. The theoretical discussion is usually confined to a vague qualitative statement about the mixing of gases and to the quantitative law that the rates of diffusion of different gases are inversely proportional to the square roots of their densities. In a practical way, nothing is done in the laboratory, and in the classroom instructors usually content themselves and their students with the spectacular experiment showing the diffusion of hydrogen through a porous clay cylinder and the consequent upward projection of a stream of colored water.

Possibly such honorable mention is all that can be accorded to this law in a first-year course in chemistry, but it is the author's opinion that a place should be made for it in a second-year course, and that there it should be given the attention it really merits. It is, therefore, with the purpose of reviving this perfectly good but partially forgotten law that the following experiments are presented.

Probably the most profitable manner of presenting the experiments here will be to put them into the same language as that used with the student. This makes them workable if anyone cares to repeat them.

THEORY.

As a basis for the theoretical discussion, it is assumed that the facts of the kinetic theory have been presented in a simple way, and that the simple kinetic equation, $PV = {}^{mm\,s^2}/_3$ has been developed. The discussion then proceeds as follows:

"We have seen that gases diffuse because their molecules are in motion. In line with this we should expect the rates of diffusion to be proportional to the speeds of the respective molecules. Now it was discovered empirically by Thomas Graham in 1832 that the rates at which different gases diffuse through a porous plug are inversely proportional to the square roots of their respective densities. Thus, if the density of hydrogen is taken as 1, the density of oxygen is 16, and the rate of diffusion for hydrogen is to the rate for oxygen as $\sqrt{16}$ is to $\sqrt{1}$, that is, as 4 is to 1. This means that a given volume of hydrogen under the same conditions of temperature and pres-

sure will pass through a porous plug in ¼ the time required for the same volume of oxygen. But this is just what we should expect, for calculation based on the kinetic theory shows that the molecular velocities of different gases are also inversely proportional to the square roots of their densities. To show this let us return to our kinetic equation. We found that $PV = m\,ns^2/3$, and from this equation we find by transposing that $s = \sqrt{3PV/mn}$. Now assume that we are dealing with hydrogen gas under standard conditions of temperature and pressure, and that we are using a volume of 1 liter. If m is the weight of one molecule and n the number of molecules, mn is the weight of the quantity of gas taken. In this case this weight is 0.09 gm. P = 76 cm. of mercury, and since the density of mercury is 13.6, the pressure exerted by a column of mercury 76 cm. high upon a surface of 1 sq. cm. is 76x13.6, or 1,033 gm. In dynes this becomes 980×1,033, or 1,013,000. V is of course 1,000 cc. Substituting values in the equation above we have:

$$s = \sqrt{\frac{3\times 1{,}013{,}000\times 1{,}000}{0.09}}, \text{ or } 183{,}900 \text{ cm. per sec.}$$

If we are dealing with oxygen gas under the same conditions as those mentioned for hydrogen, the values we should have to substitute would all be the same except that for the weight of one liter, which would be 1.429 gm. We should then have by substitution:

$$s = \sqrt{\frac{3\times 1{,}013{,}000\times 1{,}000}{1.429}}, \text{ or } 46{,}000 \text{ cm. per sec.}$$

By comparison of values, it will be noted at once that the calculated speed for hydrogen is almost exactly four times as great as that for oxygen.

"Proceeding further, we notice that no matter what gas we use, the numerator of the fraction under the radical is a constant. If, then, in comparing the expressions for two gases we were to divide through by this numerator, we should obtain in either case the expression $s = \sqrt{1/d}$, where d is the density of the gas. For the two gases we should have then, $s':s::\sqrt{1/d^2}:\sqrt{1/d'^2}$. Simplifying this, we have, $s:s'::\sqrt{d'}:\sqrt{d}$; that is, the molecular speeds of the two gases are inversely proportional to the square roots of their densities. Thus by use of the few very simple and plausible basic assumptions of

the kinetic theory we arrive at a calculated value which is in perfect accord with the empirical facts.

"Now let us see what use can be made of the law of diffusion: Since molecular weights are proportional to densities, we may substitute molecular weights for densities in our equation. We shall then have, $s:s'::\sqrt{m'}:\sqrt{m}$, where m' and m are the molecular weights of the gases whose molecular speeds or rates of diffusion are respectively s' and s. But in practical work we measure the time required for a given volume of gas to pass through a small opening or a porous diaphragm; and this time, being of course inversely proportional to the speed of the molecules, is directly proportional to the square roots of the molecular weights. If, then, we let t and t' denote the respective times of outflow required in the case of the two gases, we obtain, $t:t'::\sqrt{m}:\sqrt{m'}$. It will be seen at once that we have here at least a rough method for the determination of molecular weights. t is taken as the time required for the outflow of a given volume of oxygen. t' is the time required for the gas whose molecular weight is to be determined. m is 32, and m' is the unknown molecular weight. In its simplest form the equation then becomes:

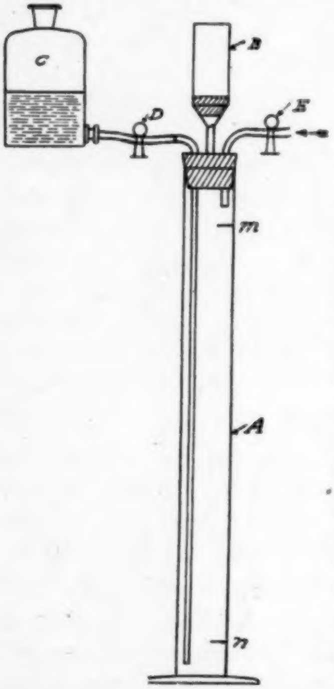
$$m' = \frac{t'^2 \times 32}{t^2}\text{,,}$$

EXPERIMENTAL.

Apparatus—The apparatus commonly used for determining rates of diffusion consists essentially of a long cylinder open at the bottom and having at the top a platinum plate pierced with a small opening. This cylinder is placed inside a larger cylinder which is also filled with water. The gas whose rate of diffusion is to be measured is placed in the smaller cylinder, and allowed to flow out through the opening under the influence of the water pressure. This apparatus has two disadvantages: First, made as it is with sealed-in thermometer, accurately ground stopcocks, and metal guides, it is expensive. Second, if a single particle of dust enters the opening in the platinum plate the outflow of the gas may be stopped altogether or diminished by possibly fifty per cent. This makes the apparatus rather unreliable. These disadvantages have probably been the main cause of the slight use of the method.

The apparatus sketched below possesses neither of the disadvantages belonging to the apparatus above described. It can

be constructed in an hour from materials usually found in any chemical laboratory, and is therefore not expensive. Best of all, the steady outflow of gas does not depend on one opening in a platinum plate, but on a million minute pores in a porous cup. For this reason the results are concordant. The following is a more accurate description: "A is a glass cylinder about 16 inches high and 1½ inches in diameter. B is an unglazed battery cup holding about 100 cc.; it is supported by a glass funnel and connected to it by means of a piece of thin rubber tubing such as is commonly used with Gooch crucibles. It will be necessary to fasten this connector in place by means of shellac or by wiring. The rest of the apparatus hardly needs description. The amount of water in C should be slightly more than sufficient to fill the cylinder up to the stopper, but not enough to rise into the porous cup. *m* and *n* are paper markers.



"*Procedure*—(1) Connect the apparatus with a cylinder of oxygen, remove the pinch-cock, D, entirely, and then allow the gas to enter —not too rapidly—until all the water is displaced from the cylinder. Continue passing the gas until the water in C is saturated (about 5 min.) and the air in B has diffused out. Now shut off the oxygen, close E, and allow the gas to be expelled through the porous cup, taking the time accurately by means of a stop watch required for the surface of the water to pass from one marker to the other. Repeat the determination, obtaining at least three concordant values. Record the average of these values.

"(2) Now substitute carbon dioxide for oxygen, and carry out the determination in the same way, not forgetting to saturate the water with the gas. Calculating from your data, decide whether the times required for the diffusion of equal volumes of oxygen and carbon dioxide are proportional to the square roots of their molecular weights.

"(3) The natural gas used in your burners is nearly pure methane, CH_4. Determine its molecular weight by the above method. Some samples of natural gas contain gasoline vapor. Gasoline is a mixture of hydrocarbons having an average molecular weight of about 100. Consequently samples of gas containing this will have a higher molecular weight than pure methane. Where the molecular weight is above 25 the gas is considered rich enough to work over for the gasoline it contains. After determining the molecular weight of this gas, decide whether it would be profitable to work it over in this way.

"(4) Determine the molecular weight of hydrogen.

"In all the above cases it must be remembered that the gas is probably saturated with water vapor, so that the value obtained is really the rate of diffusion of a mixture whose average molecular weight differs somewhat from that of the pure gas you intended to use. This is particularly so in the case of hydrogen, whose molecular weight is small. The average pressure of the mixture during diffusion is the atmospheric pressure plus that of the water head which forces the gas through the porous cup, and may be taken as about 76 cm. of mercury. Of this pressure about 74 cm. are due to the gas and about 2 cm. to the water vapor. Calculate on this basis the average molecular weight of the mixture of hydrogen and water vapor, and note how it compares with the value obtained experimentally."

RESULTS.

To show what can be done with the apparatus, the following results are appended. All the data were obtained during a single period of three hours.

(1) Time of outflow for oxygen:

1. 9.83 min.
2. 9.83 min.
3. 9.86 min.

ave. 9.84 min.

(2) Rate of diffusion of carbon dioxide:

Time of Outflow:

1. 11.23 min.
2. 11.20 min.
3. 11.25 min.

ave. 11.23 min.

$t/t' = 0.87$, $\sqrt{32}/\sqrt{44} = 0.85$.

(3) Molecular weight of hydrogen:

Time of Outflow:

1. 2.78 min.
2. 2.78 min.
3. 2.73 min.

ave. 2.76 min.

Molecular weight, 2.48.

Molecular weight of a mixture of hydrogen and water vapor calculated as above, 2.42.

(4) Molecular weight of natural gas:

Time of Outflow:

1. 7.13 min.
2. 7.13 min.
3. 7.12 min.

ave. 7.13 min.

Molecular weight, 16.6.

Calculated for pure Methane, 16.

By actual test this gas has been shown to contain no appreciable amount of gasoline.

A UNIT SYSTEM FOR LABORATORY APPARATUS.

By Oscar R. Foster.

In large city high schools, where many pupils study chemistry, it is often a serious problem to supply laboratory apparatus quickly, especially when individual work is done. In order to insure promptness at the beginning of a laboratory period and to minimize the teacher's work in large classes, the writer has devised the system here described. This method of apparatus storage and distribution is not designed to meet the needs of those chemical laboratories where provision is made for placing material in drawers beneath each table.

FIGURE 1.

The unit system is as follows: Drawers of convenient size, and as near the laboratory as circumstances permit, are used as containers for apparatus; each drawer constitutes a unit and provides sufficient dismantled apparatus for the performance of one experiment by a class. In some cases, where the quantity of material is larger, two drawers are a unit. The necessary chemicals are kept on the laboratory shelves; only chemicals which are seldom used are stored in the drawers. This system can be extended so as to include the storage of chemicals where conditions make this desirable. Figure 1 and Figure 2 show two small units, Figure 1 for the preparation and properties of

ammonia, and Figure 2 for the preparation and properties of bromine. The size of these units is about 11 in. wide × 20 in. long × 3 in. deep. For more bulky apparatus, larger units are used. Two sizes are employed, one approximately 11 in. × 20 in. × 6 in., and another about 11 in. × 20 in. × 11 in. On the inside of the far end of each drawer is placed a sketch of the set-up.

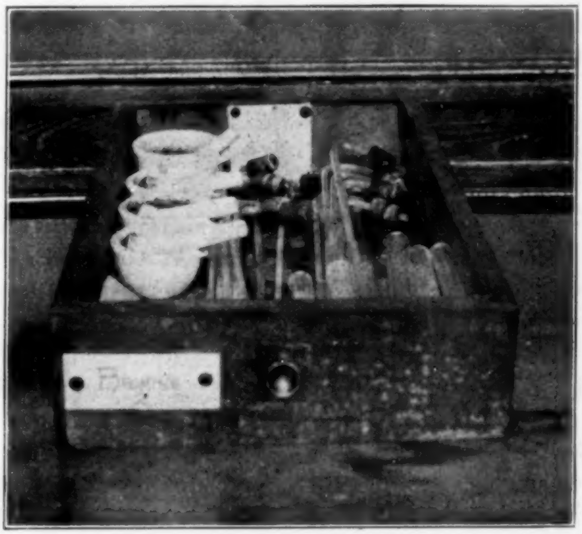


FIGURE 2.

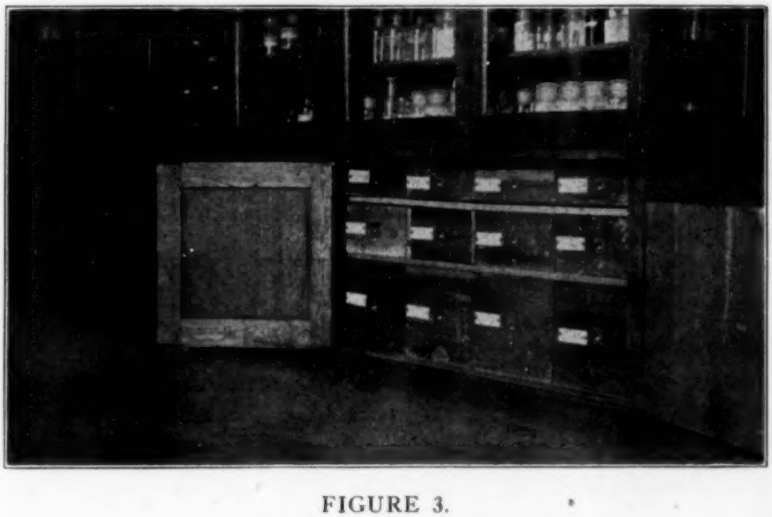


FIGURE 3.

Figure 3 shows the method of storing the units in hall cases near the chemical laboratory. Each drawer is labeled, its contents being shown in large letters. The entire space required is small. Three compartments as shown in Figure 3 (sufficing for apparatus for a one and a half year course in chemistry) have over all dimensions of 12 ft. 8 in. long × 27 in. high × 25 in. deep.

One feature of the apparatus shown in Figure 1 is worthy of special mention. The test tubes shown in the photograph are fused silica tubes; they are used in this experiment on ammonia to minimize breakage. On account of the low coefficient of expansion, these tubes will not break when there are drops of water on the inside and a Bunsen flame is directed against the outside.

Where large classes are the rule, this system lightens the purely physical work of the teacher. At the beginning of a laboratory period he brings one unit, or at most two units, into the laboratory and places the necessary reagents near them. In high schools where a laboratory assistant is available, the assistant can do this work before or during the change of classes. A brief explanation is given with blackboard illustration; then the student selects sufficient material and performs the experiment. When he has finished he dismantles the apparatus, washes it, and returns it to the drawer. The removal of the apparatus for an entire class is then easily and quickly accomplished.

The method above described possesses the following advantages:

1. Availability—the apparatus is always instantly available.
2. Minimizes effort—only a little work is required to supply material for a large class.
3. Time saving—because the necessary apparatus for an experiment is kept in one place there is no loss of time; such loss will occur if apparatus is widely distributed.
4. Compactness—apparatus for a large number of students can be stored in a small space.
5. Low cost—the cost of containers is small; existing drawers may be used. The apparatus itself can be designed so that it is extremely simple and requires no large or expensive parts.
6. Ease of inspection—the entire stock can be looked over in a short time to detect breakage and make replacements.

The photographs which illustrate this article show part of the equipment in the Manual Training High School of New York City, where this system has been in continuous operation for more than six years.

CONTRIBUTION OF THE COLLEGE TO HIGH SCHOOL SCIENCE TEACHING.[1]

BY JOHN C. HESSLER.

At the last Springfield meeting (February, 1915) the speaker presented to the Academy a report on behalf of the Committee on Secondary School Science. As he recalls that report, he feels that he would like to state again its last sentence, to the effect that however great the benefits of the Academy may be in its stimulation of amateur and professional investigation, the members of the Academy can perform no greater service for the science of the future than to improve the quality of high school science teaching in their communities. The Academy has not been unmindful of the resources of the state, in the persons of the high school teachers of science. But in the attempt to realize upon these resources it has been peculiarly unfortunate. Many of those present will remember our last experience. After sending out to science teachers some hundreds of notices regarding the work of the Academy, together with sample copies of *Transactions*, the net return was, possibly, two or three applications for membership. The result seemed to prove conclusively that the teachers of the state are not in sympathy with science.

To say that the Academy was disappointed over the failure of science teachers to respond to its efforts is to state the case mildly. But instead of consoling ourselves with having done our duty, it behooves us to study the science situation more deeply and to learn the status of the average science teacher. The lists of accredited schools issued by the State Department of Public Instruction and by the Examiner of the State University are a revelation to one who is not familiar with high school conditions. Especially is this true if one considers the small number of teachers in many of the schools, with the resultant large number of subjects to each teacher. Nowhere is the burden heavier and the effect more deplorable than in the science department, with its supposed laboratory method. A visit to a few of the smaller high schools and, alas, to some of the larger ones as well, verifies abundantly the suspicion aroused by the accredited lists. The fact is that only here and there can one find high school science being taught in a really efficient and inspiring manner.

Let us look at the situation at closer range. Let us suppose that the teacher was trained to teach chemistry. He will be found teaching physiography, physiology zoology, botany, perhaps also physics, in all of which he has had practically no

[1]Read before the Illinois Academy of Science at Galesburg, Illinois, Feb. 23, 1917.

preparation. He is fortunate if he is not called upon to teach science after preparing himself especially in English or history. I know whereof I speak. If you ask the teacher how he comes to be so far from home, he responds that he is expected to take the work assigned him. Since he had studied something of one science, he is expected to know science in general, especially if the school cannot afford more than one science teacher. Or if the school boasts of a science "faculty," he happened to be the last one engaged and was obliged to take what the other science teachers wished upon him.

But what of the pupil under this regime? Taught by a teacher who does not know his subject, who does not discriminate between the essential and the nonessential (it would be laughable, if it were not pitiable, to hear some of the absurd things stressed in such cases), a teacher who is merely holding his job until he can get into a position in which he can teach his specialty, the pupil learns science as he too often learns algebra and Caesar and composition, as things to receive grades upon, to pass off, and never to be bothered with again. Nothing of science as a life to be lived, a home to be improved, a community to be inspired, a great quest to engage in for the years to come! Is it not true that only vision and enthusiasm on the part of the teacher are at all likely to arouse vision and enthusiasm in the pupil, as only life can beget life?

But this is only one side of the subject. Suppose that the student prepared in chemistry gets his chosen job, and has the opportunity to teach chemistry only; what kind of chemistry shall he teach? Shall he teach it as chemistry adapted to the life of the community or as the ideal philosophy of the investigator? Shall it be a chemistry that takes account of the child's point of view, that fits the child's progress in science, or is the teacher to feel that the first thing to teach the pupil in high school is the last thing he himself learned at college?

Let us understand at this point that it is of no use for us to blame the young high school teacher for the situation in which he finds himself. He is but adapting himself to conditions as best he can. If the speaker has seemed to any to be spending too much time in criticizing the existing order, let such take note that the criticism is not intended to be carping, but has a constructive reason for its justification. For the imaginary, yet real, picture drawn in earlier paragraphs of this paper has its background in statistics. From an article by Professor Carl Hartman in SCHOOL SCIENCE AND MATHEMATICS for the month of

February, 1917, it appears that 13 per cent of the science teachers of Texas teach one or two subjects; 22 per cent teach all the science offered; 20 per cent teach all the science and all the mathematics, and 50 per cent teach all the science and at least one other subject.

These figures are not peculiar to Texas; they only corroborate results obtained two years ago for Illinois. Moreover, they show conclusively that there are practically no science specialists in the high schools. If we wish to seek an improvement in the quality of the teaching done we must go back of the teacher to the public that takes advantage of his inexperience to pay him a small salary, and above all we must go back to the college or university that prepares the teacher for his profession. In this connection Dr. Hartman observes that "the universities and colleges are, in the main, failing to take advantage of their opportunity of training teachers for these schools, for the reason that they tend to train specialists rather than high school teachers of science."

This last observation brings us directly to the subject of the paper. What can the college contribute to science teaching in the high school? It can, in the first place, recognize the problem. Here, in an organization devoted to *all* science, we can see it more clearly, perhaps, than in the college faculties from which we come. The self-evident remedy, if experience and reason teach us anything, is that the college and the undergraduate departments of the university must adapt a part of their instruction in science to the training of their graduates to be *teachers of science* rather than teachers of *a* science. But how can this be done? One way that suggests itself is that the college can expect those of its students who have any idea of teaching to take elementary courses in several sciences rather than to specialize in one. This will break the hearts of some instructors in advanced courses, but these may have to stand aside.

There is, however, a still better way of solving the problem. The college can select from its faculty a man who can appreciate the specialist's point of view and who can yet see the science field as a whole, a man who can make for this purpose a re-synthesis of science out of the fragments into which, for purposes of intensive study, it has been broken. This man can present to students of the third or fourth year a course in the "Teaching of Science." As a prerequisite, students should be required to take courses in both the physical and biological branches of science. The course could include a rapid survey of the special sciences from the high

school point of view. The salient principles of the sciences, the textbooks available, the laboratory facilities to be expected, the adaptation of simple apparatus where the more technical is not present, the methods of presentation, the results to be expected from students—all these could form part of such a course. In this way the elements of some sciences not ordinarily taken by college students, such as astronomy, may be added to the graduates' equipment.

The adoption of such a course will mean that in many colleges a specialist in one science will have to give the course in science teaching; in the larger schools a man will be found who can devote himself to this work alone. And the student in the larger school need not give up specialization, either. But to the student who majors in biology the teaching course will give aid in the physical sciences, while to the student of physical science it will give the necessary minimum of biology. To both classes the course will give the equipment and point of view needed for the presentation of introductory science, or general science, in the junior high school or in the first year of the ordinary high school —a need not met by any college science courses of the present time.

Some may suggest that several members of the faculty should join in giving such a course, each presenting his specialty. To such the reply is that this ought not to be a vaudeville performance; there must be *one* teacher. If the college is unable to muster enough unification of purpose to give such a course, it can not fairly expect the student to do so. Another objection will be that the specialist will not be willing to devote himself to such work, yet every month or two, even now, we hear of a science specialist who goes over into science education in a university school of education. The arrangement proposed means that it will no longer be necessary for the teacher of a science to leave the university in order that he may become a specialist in the teaching of science.

As the inexperienced high school teacher will inevitably teach in the high school the thing last studied in college, let that last thing studied be a unifying course rather than a specialized one. The result will be a rounding out of all the preparatory work done by the teacher. As a high school pupil he will have begun with an introductory science and will then have broadened out into the special sciences of the later high school and college years. Last of all, without abandoning the special skill he has gained, he will yet come to feel, before he goes out to present to the next

generation the truths of science, their essential unity. This will make of the graduate not only a better teacher, but a better man or woman.

SOME OPINIONS OF A TEACHER.

Passages from the address of Professor Trelease as President of the Illinois Academy of Science, at the recent Galesburg meeting.

"The plainest lesson of biology is that success and effectiveness lie in the partition of activity between structurally adequate units, and the aggregation of these into correlated organs and bodies and associations, sharing through specialization the common labor, and unifying it through cooperation.

"Analysis of our educational system shows that, as in commerce, three classes exist, producers, distributors, and users of knowledge. We call them discoverers, teachers, and pupils.

"Men have worked as amateurs in broadening scholarship and founding new sciences and new industries, while making their own subsistence through practicing some vocation or profession already established. . . . Our largest social system, that of education, has afforded to teachers indirectly opportunity for expansion in the field of scholarship and discovery, while invention and the application of discoveries have been promoted directly in proportion to their money-earning worth. . . . One does not need to lay his ear to the ground to hear the sounds of approaching educational organization, and among these the word research is heard very significantly.

"Practical, intelligent contact with the world they live in is what we ask for our children. . . . To the colleges fall the opportunity and duty of building onto the foundation of the school a superstructure of ambition, and of correlation and application of a broadened and deepened knowledge. . . . The task of a university seems to be to equip this with a love of productive scholarship, practice in its methods, and a wisdom that differs in kind as well as in degree from the information and knowledge of school and college.

"The ideals sought in a teacher appear to be an undying interest followed by ambition and culminating in a good workman's love for his handiwork. . . . and a capacity to share with others what he has without himself losing. . . . There is only one way of achieving this—by intimate personal contact with the truth, and that is all but synonymous with sustained contact with scholarly progress and with the underlying materials of such progress.

"In school and college few men find time or opportunity for scholarly production. The university is the real workshop: it has found means of lightening the burden of service so that time and energy remain for research beyond the set task of teaching, and it offers appliances and materials adequate to such work. By a process of natural selection, misfit investigators who cannot or will not teach and teachers who cannot or will not produce are eliminating themselves from its dual chairs.

"When I accepted a call to the University of Illinois I was entering an institution which generally pays its younger men a fair salary for twenty hours' service a week, which eases up on the amount of classroom service after they have passed into the higher grades of appointment, and which makes due allowance for duties of administration. To me this was an indication that the great establishment of which Illinois has so much reason to be proud has passed from the stage in which justification of expenditure has to be made on the basis of either clock-time or semester-student-hours spent in teaching: and that beyond this, essentially half of one's time through the college year, with a bonus of a quarter of the year in form of an entirely free vacation, is placed at his disposal for delving into the specialty that represents to him the fascinating part of life.

"So far I have found few people who look to teaching as the means of acquiring fortune, or who take the leisure it accords as a merited tribute to eminent scholarship; on the contrary, they realize that they have acquired eminence through scholarship, and they sustain both through a directed industry that constitues the chief pleasure of life for them.

"Publication becomes something of an index to productivity, a sort of Who's Who in Activity, characterizing the unsuccessful quite as well as the successful man; but its indications are read sometimes through the fads of the day, and they may not carry always their face value. Nevertheless, publication gives the most available data for judging productivity, and the day of oral transmission of knowledge has so far passed that it now constitutes the principal means of transmission of the detailed results of investigation. What is true of the individual is true of the organization. To do its work effectively it must stimulate investigation and make public its acquisitions. It is our solemn obligation to see that through publicity we make a record, collectively and individually, in which we and the state may take pride."

THE DEFLECTIVE EFFECT OF THE EARTH'S ROTATION.

By Charles F. Brooks,

Instructor in Geography, Yale University, New Haven, Conn.

Halley, the famous English astronomer, in 1686 tried to explain the oblique course of the trade winds as a result of their following the diurnal heat wave which accompanies the (apparent) westward movement of the sun around the earth. It was not until 1735, however, that the basic cause for the deflection of the winds was discovered. In that year, Hadley advanced the theory that winds with a north or south component are deflected to the west or east because they move into latitudes having increasing or decreasing rotational velocities, respectively. It was assumed that the winds merely take with them the rotationa' velocity of the latitude whence they come. The correct explanation was advanced first by Charles Tracy in 1843; but the more complete work of William Ferrel beginning in 1856 received wider recognition. The following exposition is taken mostly from Ferrel's "*A Popular Treatise on the Winds*" (New York, 1889), pages 42 to 88. Professor W. M. Davis has rendered an excellent non-mathematical account in his "*Elementary Meteorology*" (Boston, 1894), pages 101 to 108. Furthermore, Dr. Julius von Hann has published a full bibliographic summary of the earth's deflective effect, in his "*Lehrbuch der Meteorologie*" (Leipzig, 1915), pages 430 to 434.

Professor Davis's introductory paragraph on deflections runs as follows:

"The cause of the deflection of the winds from the gradients is to be found in the earth's rotation. It may be easily explained and illustrated by experiment (see pp. 106-108) that the winds cannot follow the gradients, because there arises from the earth's rotation a force that tends to deflect all horizontal motions, of whatever direction, to the right in the northern hemisphere, and to the left in the southern: the deflecting force is proportionate to the velocity of motion, and increases from zero at the equator to a maximum value at either pole." A footnote on centrifugal force adds: "Although always spoken of as a 'force,' this term implies a misconception of the same kind as that which often embarrasses the understanding of 'centrifugal force.' A body moving without friction over the surface of the earth tends to move in the direction of its first impulse. We live on the earth's surface, unconscious of its rotary movement, and consequently persuaded that any straight line holds a fixed direction. Hence, when a free-

moving body (such as a free-swinging pendulum, as in Foucault's experiment) turns aside from its first line of movement, we assume that its direction has been changed by some deflecting force. In reality, the free-moving body perseveres in its original direction, in virtue of its inertia; it is the apparently fixed line of reference that is changing its direction, in virtue of the earth's rotation. The "deflecting force" is therefore only the inertia-resistance that a free-moving body exerts against a constraining force that urges it to move in what we call a straight line or a fixed direction."

Stating this differently, Ferrel says (p. 79): "Some general idea of this deflecting force may be formed from the experience of any one in walking over a narrow drawbridge while it is turning around its central pivot. If there were no railings, the tendency would be, if not guarded against, to run off on the one side or the other, according to the direction of gyration; and where there are railings, to press against that side. And this tendency would evidently be in proportion to the velocity of transit across the bridge and the angular velocity of its gyration. Of precisely the same nature is the deflecting force of the earth's rotation; for every horizontal line, fixed relatively to the earth's surface, except at the equator, is continually changing its direction with reference to a direction fixed in space; and so a body, set in motion in any direction relative to the earth's surface, tends, if free, to depart from this direction, and if constrained to move as in a groove in his direction, to press toward one side or the other, as the case may be."

That a rotating table may be employed to illustrate the deflection, may be made clear by the following illustration (Davis, p. 108):

"Several circular discs of paper, an inch or two in diameter and each marked with a strong diametral line, may be attached to a terrestrial globe in different latitudes. Watch the diametral line on one of the discs while the globe is slowly rotated; the line will be seen to change its direction; now pointing to one part ot the room, now to another. In other words, the disc is rotating with respect to its center, and in the same direction as the globe rotates. A disc near the pole will rotate rapidly; a disc near the equator will turn its diameter more slowly from one direction to another; a disc on the equator has no motion of rotation with respect to its center; and at the equator there is no deflective force."

The angular rate of rotation of any disc is equal to the angular rate of rotation of the globe multiplied by the sine of the latitude. So, as the earth's rotation rate is constant, the angular rate of deflection of any moving body at a given latitude is constant, and is the same irrespective of the direction of motion of the body. But the actual distance of deflection in any given time depends on the body's velocity. This departure of the body from the initial direction for a very short range may be expressed by the following formula (Ferrel, p. 86):

$$d = 0.00007292\ s \sin l.\ t^2$$

in which d is the departure in meters; 0.00007292, the angular velocity of the earth's surface expressed in terms of the radius; (Ferrel, p. 62); l is the geographical latitude; s, the velocity in meters per second; t, the time in seconds.

The foregoing shows why there is deflection. The forces acting to produce it deserve further explanation. Any body on the earth is held down by gavity so that even when "at rest" it is travelling around the axis of rotation at a high speed, except in the immediate vicinity of the poles. If the earth were spherical, gravity, being equal everywhere, could not prevent the body from sliding equatorward. But it does not move equatorward because this tendency has already built up a bulge such that the pull of gravity down the slope just counterbalances the centrifugal tendency up the slope[1].

If this body or mass of air is set in motion eastward its total rotative velocity around the earth's axis becomes greater. The centrifugal force is thus increased: therefore, the body moves towards the equator, up the unchanged slope. On the other hand, the body, when given a westward motion relative to the earth's surface, suffers a diminution of its total rotative velocity. The centrifugal force, consequently, becomes insufficient to counterbalance the gravitative action and the body moves down the slope, poleward. Both of these deflections are to the right in the northern hemisphere and to the left in the southern. A vertical component of the centrifugal force tends to deflect west winds upward and east winds downward.

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[1]In general the centrifugal force = $F_c = \frac{\omega^2}{r} m$ (Ferrel p. 47), in which $\omega = rn =$ the gyratory velocity in terms of the radius, r being the radius vector and n the angular velocity; m stands for mass.

Applied to the earth this formula becomes:

$$F_c = 2\ n\ s \sin l.\ m \qquad \text{(Ferrel p. 81),}$$

where $n = 2 \frac{\pi}{86164} = 0.00007292 =$ the angular velocity of the earth's surface expressed in terms of the radius; $s =$ the velocity of the body; and $l. =$ the geographical latitude.

A body in motion equatorward is going farther from the axis of rotation. According to Kepler's second law, the radius vector describes equal areas in equal times. Thus when the radius increases, the angular velocity must decrease. But the surface of the earth at all points has the same angular velocity; and, therefore, the body in motion equatorwards is apparently deflected to the west. If the body goes poleward, on the contrary, the radius vector becomes shorter; and the angular velocity greater. The result in both cases is a deflection to the right in the northern hemisphere and to the left in the southern hemisphere.

As movements in any direction can be resolved into their meridional and latitudinal components, it is evident that there is deflection to the right in the northern and to the left in the southern hemispheré no matter in which way the body moves; a deflection which, as previously stated, is equal for all directions.[2]

Ferrel compares his results with Hadley's as follows (pp. 68-69):

"The preceding results, obtained from the principle of 841 [Kepler's principle of the preservation of areas], differ very much from those obtained form the principle adopted by Hadley, about the year 1735, in explaining the trade-winds, namely, that a body, being forced directly toward or from the pole, tends to keep its initial absolute gyratory velocity. He says:[3] 'A particle of air drawn from the tropics, where it is supposed to have no motion east or west, toward the equator acquires a westward velocity on account of the parallels continually enlarging. The increase of the parallels from the tropics to the equator is in the ratio of 917 to 1,000, and hence the westward motion in an hour is 83 miles at the equator, which is decreased by the effect of the earth's surface to what is observed.' But from what has been shown above, the velocity of a body having an absolute east velocity of 917 miles per hour at the tropics, as here supposed, would be decreased at the equator in the ratio of unity to the cosine of the latitude at the tropics, or as 1 to 0.917. Hence, instead of still having an absolute east velocity of 917 miles per

[2]This equality Ferrel proves mathematically, arriving at these three formulas:

$F_u = (2n + \nu)\, u \sin l\, m$ = eastward deflecting force with poleward velocity u.

$F_v = (2n + \nu)\, v \sin l\, m$ = equatorward deflecting force with eastward velocity v.

$F_s = (2n + \nu)\, s \sin l\, m$ = force deflecting body to right in northern hemisphere when s is the velocity of movement in any direction along the earth's surface. n = the absolute gyratory velocity; and ν = the relative gyratory velocity of the body with mass m at geographical latitude l (pp. 69-73)

"This deflecting force, however, is not a real force, but is of the same nature as centrifugal force, §35; and as it always acts, as we have just seen, in a direction at right angles to the direction of motion, its tendency is to continually change direction only, and not to increase or decrease velocity and momentum. But this change of direction must not be understood to be a change of absolute direction in space, for this would require a real force, but simply a change of direction relative to the earth's surface" (p. 73).

[3]*Concerning the Cause of the General Trade-Winds;* by Geo. Hadley, Esq. Phil. Trans., 1735.

hour, it would have a velocity of only $917 \times 0.917 = 841$ miles per hour. This being deducted from 1,000, the supposed absolute velocity of the earth's surface at the equator, we have 159 miles for the relative east velocity there, instead of 83 miles as given above.

"According to this erroneous principle, in order to obtain the relative east components of velocity of the body at the several latitudes, in moving from the equator to the pole in the preceding example, it would be necessary to subtract the absolute east velocities of the several parallels, as given in Table V, from that of the equator, and we should thus get in meters per second, at the parallel of 45°, $v = 465 - 329 = 136$ [Ferrel: $658 - 329 = 329$]; at the parallel of 60°, $v = 465 - 232 = 233$ [Ferrel: $930 - 232 = 698$]; and at the parallel of 80°, $v = 465 - 81 = 384$ [Ferrel: $2674 - 81 = 2593$]." Of course, friction and, with gases and liquids, mixing and other factors prevent the occurrence of such enormous velocities due to the earth's rotation.

Hadley's theory applied to east and west winds requires no deflection of these winds, while as a matter of fact, deflections are the same irrespective of the wind direction. Another point not mentioned by Ferrel is that if from either pole a body moves without friction along the earth's surface, the deflection according to Hadley's theory is correct, for the body has no rotational velocity. It is little wonder that Hadley's theory with its simplicity and partial truth should still be accepted as correct.[4]

Summary.

The apparent deflection of bodies moving on the earth's surface occurs because the earth turns in space while the body tends to travel in a straight line. The angular rate of deflection varies with the latitude, but is the same for motion in any direction at a given latitude. The absolute distance of deflection depends, in addition, on the velocity of the body in motion. Stated in terms of the forces involved, an eastward or a westward movement respectively increases or decreases the centrifugal force. The equilibrium between gravity and centrifugal force as maintained by the equatorial bulge is thus disturbed, and deflection results. A movement equatorward or poleward so changes the rotational velocity of the body that it is deflected to an extent equal to the deflection with eastward of westward motion. In fact, for all directions of horizontal movement there is deflection to the right in the northern hemisphere and to the left in the southern hemisphere.

[4]For instance, see: E. C. Martin, *Our Own Weather*, New York, 1913, p. 23.

HYDRAULIC ANALOGY TO THE SIMPLE ELECTRIC CELL.

By G. B. Blair,
Oregon Agricultural College.

The hydraulic analogy to the electric cell proposed by Sir Oliver Lodge, and which is employed by a number of textbooks on physics, is of admirable simplicity, but does not correspond in all respects to the conditions which are found in the actual cell. It does not make clear that there are two rises of potential in the cell with a fall of potential between them due to internal resistance. In casting about for an analogy which would be more accurate in these respects the writer hit upon the idea of introducing two centrifugal pumps in series in a closed circuit of pipe in which they cause water to circulate. The feature of the analogy which causes it to differ from those in common use is the introduction of a second pump, together with a section of pipe to represent the internal resistance of the cell. The following discussion of the electric cell is substantially that used in an introduction to a laboratory experiment on the electric cell.

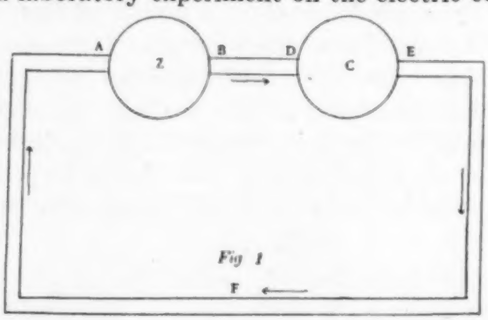


Fig 1

Z and C (Fig. 1) represent two centrifugal pumps which are connected to a circuit of pipes ABDEFA, and which cause water to circulate in the direction of the arrows. BD is a short section of pipe through which water flows from pump Z to pump C, while EFA is a long pipe through which the water returns to Z. Pressure gauges at A and B show that pump Z raises the pressure from 10 lbs. per sq. in. at A to 30 lbs. per sq. in. at B, while pressure gauges at D and E show that pump C raises the pressure from 25 lbs. per sq. in. at D to 45 lbs. per sq. in. at E. Notice that the pressure is 5 lbs. per sq. in. lower at D than it is at B. This fall in pressure is due to use of pressure in overcoming friction in the pipe BD. In the same way, the fall in pressure of 35 lbs. per sq. in. from E to A is due to friction in the long pipe EFA. Note that the *total rise in pressure* due to the pumps (20 lbs. per

sq. in. in Z and 20 lbs. per sq. in . in C) is equal to the *total fall in pressure* in the pipes (5 lbs. per sq. in. in BD and 35 lbs. per sq. in. in EA).

The maximum pressure difference which the two pumps can develop is 40 lbs. per sq. in., and, since the friction is small when the pumps are first started, on account of the slow speed of the water, the rate of flow of the water will increase until friction develops a back pressure equal to 40 lbs. per sq. in. and then the flow will become steady. It is clear that this rate of flow will depend upon the maximum pressure difference which the pumps can maintain and upon the factors which determine the friction, i. e., upon the resistance which the pipe offers to the flow of the water.

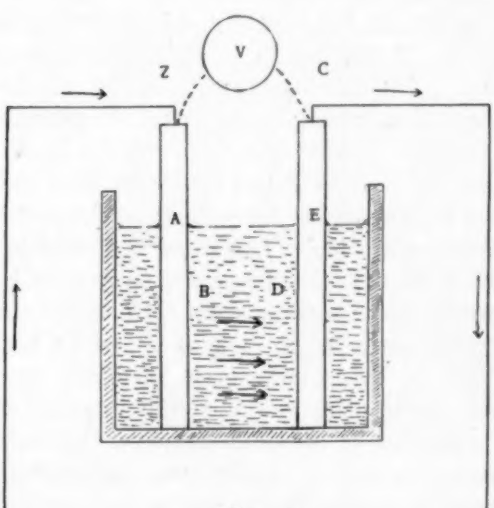


Fig 2

In the simple electric cell (Fig. 2) we have a case analogous to the water system in Fig. 1. The chemical action in the battery solution raises the electrical pressure or *potential* in the layer of solution B close to the zinc plate, Z, to a value about 0.62 volt above that at A on the plate itself. Similarly, the chemical action raises the potential at E on the copper plate above the potential in the layer near the plate by about 0.46 volt. The sum of these rises in potential, 1.08 volts, is called the *electromotive force* of the cell and corresponds to the total rise in pressure, 40 lbs. per sq. in., produced by the pumps in Fig. 1.

When the plates of the cell are connected by means of the wire CFZ, electricity will begin to flow through it in the direction of

the arrows and *the rate of flow*, that is, *the current*, will increase until the "electrical friction" in the external resistance, CFZ, plus that in the internal resistance, BD, just counterbalances the electromotive force of the cell when the current will become constant. This condition of steady flow is reached when the rate of consumption of energy in heating the wire is just equal to the rate at which energy is supplied by the chemical action in the cell. The current rises to its full value in a very small fraction of a second. When the voltmeter, V, is connected by means of two short wires to Z and C it reads the *difference of potential* between them. This difference in potential corresponds to the difference in water pressure between A and E in Fig. 1 (35 lbs. per sq. in.). Suppose that the reading of the voltmeter is found to be 0.8 volt. This 0.8 volt is then the fall in potential in the external resistance, CFZ, just as the 35 lbs. per sq. in. is the fall in pressure in the long pipe EFA. The fall in potential in the cell itself may be found by subtracting the fall in the external resistance, 0.8 volt, from the total rise, 1.08 volts (the electromotive force) just as the fall in the pipe BD may be found by subtracting the fall in the longer pipe, 35 lbs. per sq. in., from the total rise produced by the pumps, 40 lbs. per sq. in. The fall of potential in the cell is therefore 0.28 volt. The electromotive force may be found by reading the voltmeter when the wire CFZ is not connected to the cell. Since practically no current is flowing no pressure is being expended in overcoming resistance and the voltmeter reads the total rise in pressure due to the chemical action.

Since the difference of potential between the ends of the external resistance, as well as the difference of potential between the two surfaces of the liquid adjacent to the plates Z and C are known, it is only necessary to find the current through the circuit in order to calculate the external and internal resistances from Ohm's law. An ammeter connected somewhere in the external resistance CFZ will give this current.

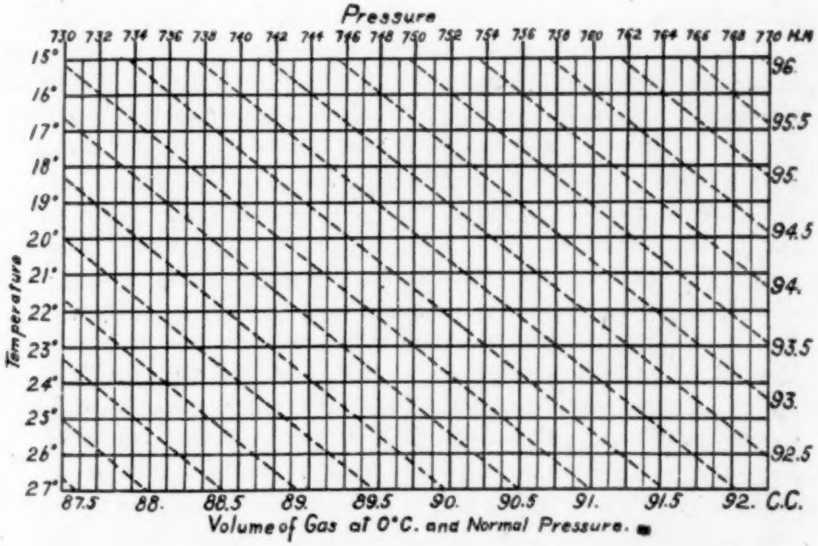
A RAPID METHOD OF GAS STANDARDIZATION.

By E. M. Cunningham,
High School, San Jose, Cal.

Every teacher of chemistry and physics has found that the mathematical work connected with the standardization of gases is both laborious and time-consuming. This is especially true of drill work in connection with the study and the applications following the study of Boyle's and Charles' laws. In my classes in chemistry, I have, in the past, either trusted to a comparison of

students' answers or else have used valuable time in the solution of these problems with a possibility of error in the process.

Again the students, after having mastered the underlying principles of these laws, have in turn consumed their time on the operations, which consist, as teachers know, of subtractions and multiplications and divisions of difficult numbers. This process has at times overshadowed, in the minds of the pupils, the real problem involved; for example, the determining of the weight of a liter of oxygen or finding the equivalent of sodium or magnesium.



Aiming to avoid these difficulties, I have devised with considerable labor the accompanying chart and am offering it to my brother science teachers in the hope that it will be found as useful to them as it is to me.

Suppose 140cc. of gas is obtained under a pressure of 764mm. and a temperature of 20° C. and it is necessary to standardize. On the chart *trace downward to the intersection of the given temperature and pressure; thence diagonally following a broken line to the standardized volume for every 100cc. of gas taken.* Multiply this volume by 1.40 (there being 140cc. of gas) and the result gives the required standardized volume of gas. If a reasonable amount of care be taken the answer is correct to the first decimal place.

The scope of the chart is sufficient to include the usual problems. The corrections for vapor density and the difference of levels may be made and the final pressure will fall within the chart's range in most cases. This chart may have other uses. I am presenting it for the purpose of gas standardization only.

SOME INTERESTING HISTORY ABOUT DR. JOSEPH PRIESTLEY.

BY LESLIE HART, Master of Science,
Conway Hall, Carlisle, Pa.

Among the relics stored in the Dickinson College Museum, none attracts more attention than the burning lens of Dr. Joseph Priestley, the discoverer of oxygen and devout champion of the phlogiston theory of chemical reactions. This lens was used by the famous chemist in his epoch-making discovery of "dephlogisticated air," as he named the new gas. Let Priestley tell his own story:

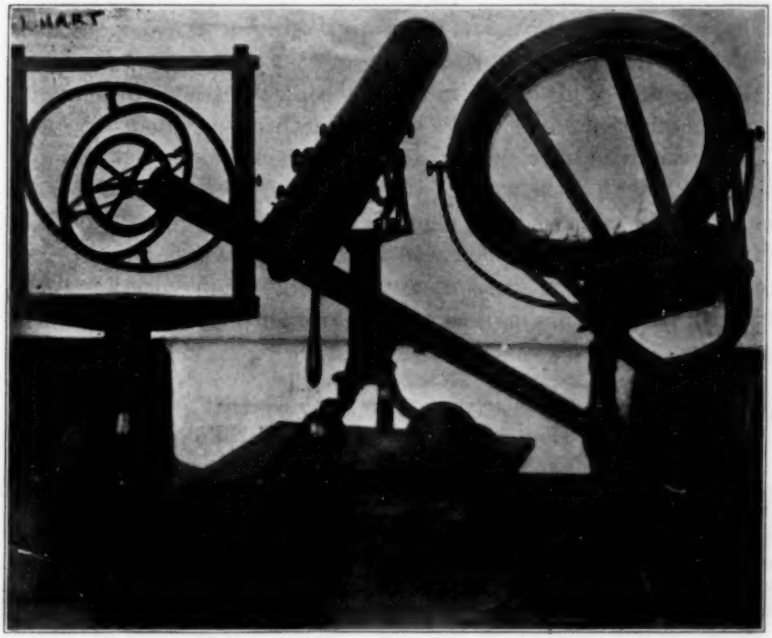
"Having procured a lens of twelve inches diameter and twenty inches focal distance, I proceeded with the greatest alacrity, by the help of it, to discover what kind of air a great variety of substances would yield, putting them into the vessel, which I filled with quicksilver and kept inverted in a basin of the same . . . With this apparatus, after a variety of experiments, . . . on the first of August, 1774, I endeavored to extract air from mercurius calcinatus per se; and I presently found that, by means of this lens, air was expelled from it very readily. Having got about three or four times as much as the bulk of my materials, I admitted water into it, and found that it was not imbibed by it. But what surprised me more than I can express was that a candle burned in this air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air, exposed to iron or liver of sulphur; but as I had got nothing like this remarkable appearance from any kind of air besides this particular modification of vitrous air, and I knew no vitrous acid was used in the preparation of mercurius calcinatus, I was utterly at a loss to account for it."

This new air was, of course, oxygen. Mercurius calcinatus was red oxide of mercury. Priestley at once began to examine it by a long series of careful experiments, in which he discovered the most important properties of the gas. In 1790, some years later, he summarized these properties:

"It is this ingredient in the atmospheric air that enables it to support combustion and animal life. By means of it most intense heat may be produced, and in the purest of it animals will live nearly five times as long as in an equal quantity of atmospheric air. In respiration part of this air, passing through the membranes of the lungs, unites with the blood, and imparts to it its florid color, while the remainder, uniting with phlogiston, ex-

haled from venous blood, forms fixed air. It is dephlogisticated air that enables fishes to live in water with which it has combined."

Priestley moved to America in 1794, settling in Northumberland. While living there he became acquainted with Thomas Cooper, one of the foremost American chemists of his day, and at that time Professor of Chemistry at Dickinson College. Professor Cooper's "Practical Treatise on Dyeing" was the first comprehensive book on the subject to be printed in English. England had furnished one small and practically worthless text on the subject, and America, two works, neither of them treating



of the chemical side of the subject. It was through the efforts of Professor Cooper that Priestley's apparatus was obtained for the college.

The veteran scientist and theologian was received in America with honors better befitting his achievements, as compared with his reception in England, where a fanatical mob stormed his house and burned valuable papers and apparatus. He was proffered the Chair of Chemistry at the University of Pennsylvania, but declined.

Priestley was not only a chemist, but an investigator in other

realms of natural science as well. His two telescopes, also in the Dickinson Museum, bear mute witness to his love for astronomy. His air gun, another of his inventions in the possession of the college, prove his interest in physics. Francis Jeffrey, the critic of the *Edinborough Review*, said that Priestley wrote more, and on a greater variety of subjects, than any other English author. He was a scientist, historian, economist, educator, grammarian, and theologian. His *History of Electricity*, written at Franklin s suggestion, was considered an authority. His *Lectures on History and Economics*, published in London in 1793, attracted special attention. His sermons and discourses were better known in his time than his scientific investigations. His *Essay on Education*, 1764, unpopular and radical in its day, contains many suggestions which are now carried out.

To the day of his death, in 1804, Joseph Priestley worked with unremitting toil. His last days on earth exemplified the ideal of so many men of science, that their lives be chiefly of value for the betterment of the world. He told his physician that he would be perfectly content with death if they would only prolong his life for half a year until he could complete the revision and printing of his works. It was this spirit of labor and love that enabled him to carry on his investigations through poverty, difficulties, controversies and even persecution.

CHEMISTRY LABORATORY ORGANIZATION AND MANAGEMENT AT COLUMBIA UNIVERSITY.

A course on Laboratory Organization and Management is offered in connection with the summer session at Columbia University by Prof. Thomas B. Freas and Prof. W. L. Estabrooke. This course is unique in character and content. No other course of its kind is given in any other university in the world. A short extract taken from a special booklet, which may be had upon application to the Director of Summer Session, or Department of Chemistry, is here given.

The course is planned to take the student's full time for six weeks. The subjects carried will be: location, laboratory construction, ventilation, etc., of buildings; laboratory equipment, including desks, lockers, shops, gas, electricity, water, suction, liquid, and compressed air, balances, etc.; buying from foreign and domestic markets, economic and scientific handling of supplies; organization of stockroom employees and their cooperation with the teaching staff; glass blowing by a professional glass blower will be a special feature; a series of trips in and about New York to manufacturing establishments, industrial and university laboratories, including trips to Boston, Washington, D. C., Niagara Falls, Buffalo, Rochester, Syracuse, and Philadelphia, in which there will be opportunity to observe actual application of chemistry to needs of the country from the most modern viewpoint, and especially the needs of university, college, and research laboratories in order to meet the demands of modern chemistry.

DEPARTMENT OF MATHEMATICS QUESTIONS AND ANSWERS.

Conducted by Herbert E. Cobb.
Lewis Institute, Chicago.

For the many mathematics teachers who are entering the profession every year, and for those who after some years of work and study find themselves at times in doubt concerning questions of subject matter, methods, devices to interest pupils, the history, psychology, or bibliography of mathematics, special problems and the like, this department is established. Probably the question that is perplexing some teacher at the present time has been faced and successfully answered by many others.

It is hoped that many will make use of this opportunity, not only to send in questions, but also to furnish replies to questions already published. Brief discussions, from two hundred to three hundred words, of points brought out in the questions will be appreciated. Address all communications to H. E. Cobb, Lewis Institute, Chicago.

Answers.

2. About what is the minimum number of original exercises in plane geometry that should be required of a tenth grade class which devotes the entire school year to the subject?

Answer by Emma C. Ackermann, High School, Lockport, Ill.

Original examples should be a definite part of the course in geometry; and with most pupils it is a real pleasure. There is an appreciable number from whom an original of any difficulty could no more be *required* than a piece of poetry. The originals should be graded; and very simple ones assigned at the very first; to solve these gives the pupils a greater respect for the subject. It is much more satisfactory to assign simple originals in class and ask the pupils to solve them during the class period than to assign more difficult ones and expect a class of uneven ability to solve them. The poor ones are apt to copy. Another way to take care of original work is to assign more difficult exercises as "honor problems;" for these, those who solve them without help may receive extra credit at the close of each month. The teacher may use any convenient method for checking up on these. This has the advantage of encouraging the brighter pupils without burdening the weaker ones with a feeling of their shortcomings.

Another good way to develop original work is to make an advance theorem an original. This is a difficult thing to manage with frequency in a class period of limited time—but it pays. The pupil has an advance theorem put before him; he is asked to interpret its language, to decide for himself the hypothesis and conclusion—a thing which he will not do for himself when he has the printed page before him. Doing this work under the supervision of the teacher means for a large number of the class just so much more original thinking. During one semester of plane geometry, I managed, by taking advantage of two short periods, to have each student copy in loose-leaf notebooks all the theorems for three weeks in advance and each was treated during the class hour as an original as far as possible. The experiment was very satisfactory and very illuminating. I found that pupils depend too much on the text for the interpretation of the theorem into a figure, for exact ideas of the hypothesis and conclusion and for methods of attack in the proof. There was also this further advantage. After the student had tried for himself various

methods of proving, he studied the one given in the text with far more interest.

Original work should be continually encouraged, both by the use of the text and a large number of originals, which varies from year to year.

4. One method of construction: On a given line, AB, to construct any regular polygon. With A and B as centers and radius AB, describe arcs intersecting at D below AB and at 6 above AB. Join D6 intersecting AB at C; this line will contain the centers of all polygons. On C6 make C4 equal to AC. Find 5, the midpoint of 46. From 6 mark off on C6 produced the points 7, 8, 9, etc., with 45 as a radius. The points 4, 5, 6, 7, etc., are centers of circles, in which AB is the side of a regular inscribed polygen of 4, 5, 6, 7, etc., sides. The construction can easily be proved exactly for the square and hexagon. It is approximate for the other polygons. Thus, for the regular octagon this construction gives the tangent of the half angle at the vertex as $2\sqrt{3}-1$, instead of $\sqrt{2}+1$, which is the tangent of $67\frac{1}{2}°$.

Question.

10. Has anyone a method of getting pupils to do the home work, without requiring them to bring in all the assigned problems worked out on paper?

THE JOHNS HOPKINS UNIVERSITY.

After spending forty years in its old quarters in the heart of the city, the Johns Hopkins University last autumn moved to Homewood, its new one-hundred-twenty-three-acre site in the northern part of Baltimore.

With its new advantages and its increased facilities, the University hopes to increase its services to American education.

A NEW DEGREE.

The University of California has recently established a new degree—that of Graduate of Education—given from its School of Education. Mr. Percy E. Rowell, Director of its A-to-Zed School, Berkeley, Cal., has the honor of receiving this degree first. It was conferred upon him at the May convocation of the University. His thesis was, "Introductory Science an Educational Means."

A COURSE IN THE METHODS OF TEACHING GENERAL SCIENCE.

The University of California is to give a course in the methods of teaching introductory general science, at the coming summer session. This course will be especially valuable, as the State Department of Education has decided that all entrants to the state normal schools must offer a course in general science for admission after August, 1917.

The course will take up the history of the development of the subject, a consideration of the aims and purposes to be attained, with a criticism of all the texts from that viewpoint. Special methods of the recitation and of the laboratory will be presented, and the course will be illustrated with many simple experiments, performed for the most part by the use of ordinary articles as apparatus. The students will be given an opportunity of making apparatus and of performing the experiments.

Mr. Percy E. Rowell will have charge of the course which will be in the School of Education, credit being given in that department.

A HIGH SCHOOL BOY'S EFFICIENCY SCORE SHEET.

By Willis E. Tower,
Englewood High School.

A few weeks since, in a boys' class in physics, two topics came up for discussion. One, the conditions making for the efficiency of a machine; the other, the use of a score sheet in comparing an object with a standard and the determination of a score upon a scale of 100.

The possibility of preparing a score sheet for a boy was taken up, and assistance from various sources obtained. An article on "Efficiency" in the *Independent* was of much use in suggesting questions. The final result is given below. The boys are showing much interest in securing the questions and scoring themselves.

This score sheet is provided so as to give boys in the Englewood High School an opportunity of checking up their activities, habits, and abilities which have a positive bearing upon their success as citizens and business men.

Each question may be graded 10, if the requirements of the question are fully met. In other cases, use a grade that will fairly and honestly represent the situation. The sum of the grades gives the score.

1. (a) Are you physically sound?............(5)............
   (b) Are you up to standard in weight and height for your age?............(5)............

(Our Physical Director may help you to answer these questions, or your physician, or consult the height and weight tables on the Englebooster Bulletin Board, near the front entrance to the school.)

2. Do you *regularly* take part in outdoor sports; as swimming, skating, tennis, golf, etc., or have an occupation that keeps you outofdoors for two hours daily?............(10)............

3. Can you play a musical instrument so well that both you and the neighbors enjoy it? *Or* can you draw effectively? *Or* have you a *hobby* that will be of lasting interest and value to you? (Such as photography, collecting stamps, wireless, etc.)....(10)............

4. (a) Are you accustomed to use carpenters' tools, garden tools?............(5)............
   (b) Have you daily home work to do helping your father and mother?............(5)............
5. (a) Do you examine regularly at least three magazines?....(5)............
   (b) Are you acquainted with the early lives of the four men you admire most?............(5)............
6. (a) Have you decided upon your life work or vocation?......(5)............
   (b) Are you actually doing work at the present time that is directly preparing you for your life work?............(5)............
7. (a) Do you give careful attention to your personal appearance?............(5)............
   (b) Is your language always clean?............(5)............
8. Do you reach at least eighty-five per cent in four regular studies? ....(10)............
9. (a) Did you ever hunt a job for yourself—and secure it?.. (5)............
   (b) Do you earn money regularly and keep a bank account? ....(5)............
10. (a) Is your best friend one of your parents, to whom you are willing to tell everything? ....(5)............
    (b) Are you prompt, courteous, thoughtful, dependable, accurate? ....(5)............

Total Score..

Name...Date...

Each boy in the Englewood High School is asked to score himself upon the efficiency sheet given above, writing also his name, date, and the total score, and return the sheet to the Englebooster Office for his own future reference. This sheet will be carefully preserved.

Every boy turning in an efficiency sheet is invited to fill out another one, one year later, for the purpose of comparison and determining his increase in efficiency.

RECOMMENDATIONS PASSED BY BIOLOGICAL CONFERENCE AND CONCURRED IN BY ENTIRE CLUB, MARCH 28, 1917.

It is the opinion of the Biological Conference of the Michigan Schoolmasters' Club that general science is worthy of university recognition, because:

1. The subject is adapted to pupils entering high school.

2. It awakens interest in science in a way that the specialized sciences cannot do with young pupils, for it is organized about the common phenomena of daily life.

3. It has the value of preparing pupils for the later sciences in the high school course, and in preparation for life of those pupils who leave school before graduation.

4. It does not make science easy (snap course) rather than thorough; it can be safeguarded, as are other courses, before recognition is granted. Following are the ways in which it may be safeguarded: (a) a student, to get credit for general science, should take it before any specialized science course (botany, zoology, biology, physics, chemistry, physiography, hygiene, or physiology); (b) textbooks on general science should contain enough material for a year's work; (c) laboratory work, on the average of two periods a week, should be required; such work may be demonstrations, individual work by students, or field trips. Laboratory records should be kept. There are several very good general science laboratory manuals at present; (d) the general science instructor should be teaching at least one of the specialized sciences in addition to general science, or have had one college course of the physical or biological sciences.

5. General science, in the majority of Michigan high schools, is safeguarded as above.

6. The majority of general science instructors in Michigan believe that it merits recognition.

Therefore, the conference recommends that one unit of entrance credit be given for high school general science to students who come from accredited schools, *provided*:

1. That the course is a full year's course.

2. That one hundred twenty full, sixty-minute periods are spent on the course, each laboratory period to count as one period of recitation.

3. That laboratory work (consisting of demonstrations, individual work, or field trips) on the average of twice a week, is done in connection with the recitation.

4. That for laboratory work there is available equipment used in the specialized sciences, together with what may be needed for general science.

5. That the general science instructor shall, in addition, teach at least one of the specialized sciences, or shall have had one course of college physical or biological science.

It is also recommended that, where the course is half a year in length, it be accepted as one-half unit, if accompanied by one-half unit in physiology, hygiene, botany, zoology, physiography or physiology.

A NEW CATALOGUE OF LANTERN SLIDES.

One of the most comprehensive catalogues of lantern slides which the writer has ever seen is Catalogue S, issued by the McIntosh Stereopticon Co., 30 East Randolph St., Chicago. In this book is given a most complete list of slides covering all phases of school work. Since the stereopticon has become such a valuable adjunct in the proper teaching of Science, History and kindred subjects, it is incumbent upon all progressive teachers to have at their command the very best slides possible to obtain. Teachers and school boards will make no mistake if they purchase material, lanterns and slides from this firm. Send at once for their catalogues, after which order material now for next fall's work.

SOME WORDS COMMONLY MISSPELLED IN CHEMISTRY.

This list is not complete by any means. Teachers should bear down heavily on pupils who do not spell correctly these words and others in their notebooks and other written work:

caetylene	crystallized	occurrence
ammonia	disappear	odor
analyzed	dissolve	oxygen
aqueous	effervesce	precipitate
chlorine	filtration	preparation.
chromium	fluorine	separate
coefficient	grease	soluble
combustible	laboratory	unites
concentrated	metallic	volatile

STENOGRAPHERS AND TYPEWRITERS WANTED—MEN AND WOMEN.

Greatly increased demands for stenographers and typewriters in the United States Government service at Washington, D. C., owing to the present emergency, require frequent examinations. Appointments in large numbers are to be made as soon as eligibles are available. It is the manifest duty of citizens with this special knowledge to use it at this time where it will be of most value to the government.

For the present, examinations for the Departmental Service, for both men and women, will be held every Tuesday, in four hundred of the principal cities of the United States, and applications may be filed with the Commission at Washington, D. C., at any time.

The entrance salary ranges from $900 to $1,200 a year. Advancement of capable employees is reasonably rapid.

Applicants must have reached their eighteenth birthday on the date of examination.

The government service offers a desirable field to bright and ambitious persons.

For full information in regard to the scope and character of the examination, and for application forms, address the U. S. Civil Service Commission, Washington, D. C., or the Secretary of the U. S. Civil Service Board of Examiners at any of the following named cities: Boston, Mass.; New York, N. Y.; Philadelphia, Pa.; Atlanta, Ga.; Cincinnati, Ohio; Chicago, Ill.; St. Paul, Minn.; St. Louis, Mo.; New Orleans, La.; Seattle, Wash.; San Francisco, Cal.; Honolulu, Hawaii; and San Juan, Porto Rico.

John A. McIlhenny,
President, U. S. Civil Service Commission, Washington, D. C.

A QUANTITATIVE ANALYSIS OF GENERAL SCIENCE.

By H. A. Webb,
Department of Chemistry, West Tennessee State Normal School, Memphis, Tenn.

I. What is General Science?

What is General Science? We have almost as many answers as there are interested persons. A new way of teaching science, all admit, but whether its pedagogical structure is built on rock or sand has not been settled by the argument. Proponents and opponents have respectively designated its principles as fundamentals and fads, with little mutual conviction.

Why is General Science? "A protest against the quantity of theory taught in chemistry, physics, physiology, biology, geology, etc.," says one. "An attempt to check the waning popularity of the sciences," (U. S. Commissioner of Education *Report* for 1890-1910, published 1910), "Humanizing and vitalizing the subject matter of science," "Bread pills for children afflicted with mental anaemia," "A revolt from college domination of high school courses," "A scientific hash of all ingredients, with plenty of soup," "An introduction to various sciences, so that the student may be inspired to further study," "A smattering of all sciences, so that the students 'know it all earlier than usual," are heard in alternating chorus. "What is General Science?" I have applied the method of the quantitative analyst to the only things upon which I could lay my hands—the texts which have been published on that subject.

Ten texts on General Science have been advertised in School Science and Mathematics during the past year. I have heard of at least one other text, but its sale has not been pushed by advertising. In order of their publication, they are as follows:

Book No.	Date of publication	Number of pages	Description
1	1905	234	A text
2	1911	295	A reference manual
3	1913	193	A lab. manual
4	1914	302	A text
5	1914	460	A text
6	1915	460	A text
7	1915	467	A text
8	1916	418	A text
9	1916	584	A text
10	1916	197	A lab. manual

A few of the above texts have laboratory manuals which accompany them, but I have not included these manuals in this

quantitative study, because of the close resemblance which each bears to the parent in content. To include them in these calculations would unnecessarily complicate the figures, without materially changing the results.

II. The Purpose of General Science Texts.

Ever since the first four verses of the *Gospel* according to Saint Luke were written, a preface, explaining the object of a book, has been considered necessary. Truly, there is a reason for general science, and thus, in excerpts from their prefaces, do the texts declare themselves—

"An introduction to science, presenting a thorough course in the science of common phenomena—mysteries explained—ideas clarified—on completion, the student should be fitted to take up science studies—should have a store of serviceable knowledge."

"'All roads lead to Rome' in a general science course, and all the pupil needs is guidance—the temptation to specialize in some particular part which the teacher likes best must be resisted, or the course ceases to be general.—Knowing a little about many sciences gives a bird's-eye view of all—overcome narrowness! —stimulate ambition!"

"General knowledge is not necessarily superficial, and children can learn all branches of science. The phenomena of environment furnish the most valuable field of study for a child, and for this a blending of all branches of science is inevitable."

"The lack of abundant, concrete and rationalized experience makes it extremely difficult for children to thoroughly master any one of the differentiated sciences as usually presented in first year high schools. The object is to develop a more usable fund of knowledge about common things, and a more scientific attitude in interpreting common problems. The difficulties which arise in the selection of material for a general science course are largely those of elimination, for the richness of the field is embarrassing."

"All subjects of elementary science are treated so that the student can find out for himself what he wishes to study later in the course. The main effort is to call attention to things that can be seen and appreciated."

"The first science of the high school should be fundamental to the entire field of science. With the immeasurable enlargement of high school courses by the introduction of many new scientific and vocational branches, the demand for a first year science becomes imperative. Uncommon thinking about com-

mon things is to be stimulated, so that modern inventions may be tools, not toys."

"Young high school students should be started on scientific projects which will influence for good their present lives, and equally, though differently perhaps, their future lives. The commonest everyday articles are proper objects for study."

"All high school pupils, even those who elect courses not directly connected with any science, should be required to broaden their general scientific knowledge—hence this book. A desire for health, a logical method of thinking, an appetite for more scientific knowledge should be created. In all this, the live teacher is the greatest factor."

"A first year high school course in science should *not* be a survey of the entire field of nature, in order that the pupil may decide which of the special sciences he likes best. Neither is general science primarily a foundation to any special science. Its primary function is to give a rational, orderly, scientific understanding of the pupil's environment, so that he may to some extent correctly interpret and master his environment. A general science course must be justified by its intrinsic value as a training for life's work."

"The chief cause for failure to get desired results with beginning classes in high school sciences lies in the character of the material chosen. From scattered sources that which will appeal to beginners has been brought together, and the funds of life experiences have been freely used as a basis for general and elementary scientific instruction. The interests of the individual have both personal and community aspects, hence topics in social science are included. The unity of the course is secured by grouping the interests of the pupils rather than the principles of any branch of science."

There is considerable unanimity in the expressions of these authors. A condensed summary of the purposes of general science might be made by some as follows: "Answer the insistent questions of adolescent youth; truthfully if you can, but answer!" "Let none plunge into the pool of life without a sprinkling showerbath of scientific knowledge!" "The cafeteria plan supplies both speed and service, hence spread all science in dishes before the pupil, so that he may choose for himself!" But lest my facetiousness be misjudged by those to whom levity is blasphemy when directed toward their idols, let me commit myself as impressed with the earnestness and logic of the mildly argumentative expressions in the prefaces of these texts.

III. Subject Matter of General Science Texts.

Subject matter is fundamental, whether in things concrete, like a stone, or abstract, like a thought. Subject matter is quantitative, and hence an interpretation of the following analytical tables and charts will, I believe, correctly express the true nature of general science as at present constituted.

Is General Science a hodge-podge? Is it superficial? Do its exponents have personal hobbies, teaching and writing with emphasis on their specialty? Is it not presumption to attempt to answer these, and other questions without a quantitative study of the subject matter of general science?

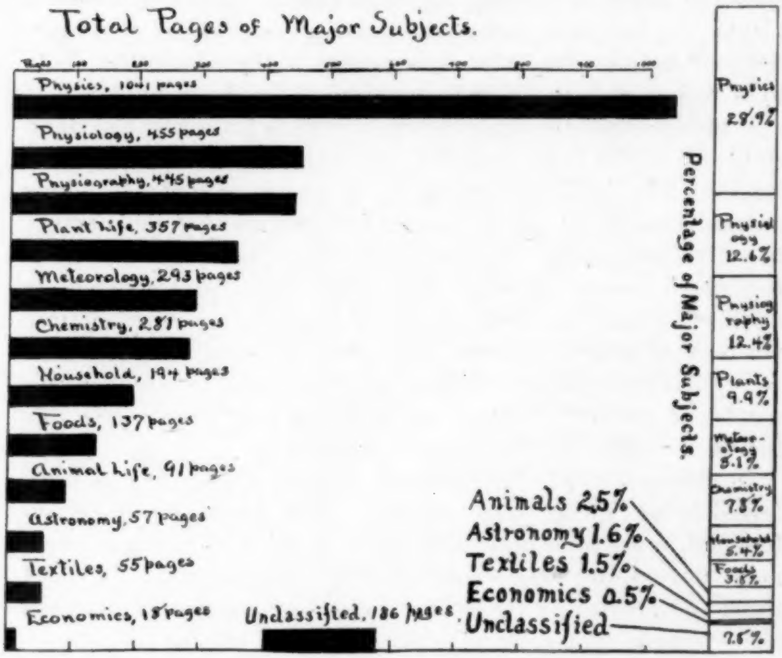
In the ten texts, there were in all 3,610 pages of instruction, all tables of contents, introductions, appendices and indices excluded. Every topic to which as much as one page was devoted was entered in a card index, each text being credited with the proper number of pages for each subject. There were in all 84 such topics of minor rank (Table 1). The only force with which I uphold this classification and count is that of my personal judgment, acquired through at least some little teaching experience with every branch of science from which the material of these texts came.

The next chart (Table 2) is a bold trespass into the holy of holies of the high priests of general science. It shows the comparative percentage and number of pages devoted to the twelve major groups into which it seemed possible to most easily condense the 84 minor topics. Here, again, I offer my personal judgment in assigning each topic to the proper "special science" to which it seems to belong, and I only ask that this act of heresy toward the creeds of general science be pardoned for the sake of the unregenerate who can better interpret the table if calculated in terms of the more familiar sciences. This graphic representation, in addition, links together old sciences and new texts, making possible some instructive comparisons.

The teachers of the old order certainly cannot quarrel with the pioneers of general science for having chosen physics as the subject of widest study. Herbert Spencer, in a revised edition of "What Knowledge is of Most Worth" would commend them for the high rank of physiology in this selection of subject matter. Those to whom the phrase "man and his immediate environment" appeals will be gratified at the well-balanced relation of physiology, physiography, and plant life. The teacher of chemistry may be a little disappointed, as he has been ac-

Mechanical Energy, 206 pages.
Household Articles, 166 pages.
Heat, Its Laws, 143 pages.
Sanitation, -Cause of Disease, 141 pages.
The Weather, 129 pages.
Electricity, Static and Current, 123 pages.
Human Physiology, (except Digestion,) 119 pages.
Light, 115 pages.
Soil, its Formation and Constituents, 108 pages.
Foods, Composition and Preparation, 105 pages.
Erosion, Wind and Water, 96 pages.
Air, its Physical Properties, 96 pp.
Water Supply, its Purification, 91pp.
Bacteria, Yeasts and Molds, 72 pages.
Carbon, inorganic, 68 pages.
Plant structure, 64 pages.
Water, Physical Properties, 58 pp.
Astronomy, 57 pages.
Plants, Their Growth, 57 pages.
Elements, C'm'p'ds, M'x's, 54 pp.
Mountains and Plains, 54 pages.
Magnetism, 49 pages.
Cleansing Agents, 48 pages.
Combustion, 46 pages.
Digestion, 45 pages.
Plants, Relation to Man, 41 pages.
Climate, 41 pages.
Reproduction of Plants, 40 pages.
Ventilation, 40 pages.
Air, Chemical Composition, 40 pp.
Animals, Invertebrate, 39 pages.
Matter, its Properties, 38 pages.
The Earth as a Planet, 37 pages.
Sound, 36 pages.
Pumps, 35 pages.
Weights and Measures, 34 pages.
Liquids, Laws of, 32 pages.
Fuels, 30 pages.
Irrigation and Drainage, 29 pages.
Animals, Vertebrate, (not Man) 28 pp.
Rocks, Composition, etc., 27 pages.
Glaciers, 25 pages.
Acids, Bases, Salts, 25 pages.
Engines, Steam, 24 pages.
The Ocean, 23 pages.
Engines, Gas, 23 pages.
The Seasons, 20 pages.
Volcanoes, Earthquakes, 20 pages.
Coast Lines, 20 pages.
Variation and Selection, 20 pages.
Drugs and Patent Medicines, 19 pp.
Ice Making, 19 pages.
Parasites on Plants, 17 pages.
Metals, Properties, Uses, 16 pp.
Gas Laws, 15 pages.
Water, Chemical Properties, 14 pp.
Forestry, 12 pages.
Farm Animals, 11 pages.
Humidity in Rooms, 10 pages.
Fertilizers, Natural, 10 pages.
Bread Making Processes, 10 pages.
Clothing, 10 pages.
Gardening, 9 pages.
Baking Powder, 9 pages.
Bleaching, 8 pages.
Paints and Oils, 8 pages.
Occupations of Man, 8 pages.
Formation of Coal, 8 pages.
Fertilizers, Commercial, 7 pages.
Heredity, 7 pages.
Commerce, 6 pages.
Dyeing, 6 pages.
Matches, 5 pages.
Time Measurement, 4 pages.
Birds, 3 pages.
Reproduction, Animals, 3 pages.
Man's Place in Nature, 3 pages.
Flavors and Perfumes, 2 pages.
Cost of Living, 2 pages.
The Higher Life, 2 pages.
Fireproofing, 1 page.
Waterproofing, 1 page.
Drawing, 1 page.
Blue Print Paper, 1 page.

customed to equality with physics in length of course and amount of subject matter taught. Chemistry is fundamental to all sciences, of course, but perhaps illustrations of its phenomena are not as apparent in everyday life as are those of mechanics, light, heat, etc., the vital processes of the human body, the forms of land and sea, or the plant life surrounding us. The chemistry



teacher can really quarrel with but one author, that of text number 5, who wrote so much concerning physiography and meteorology that he had room for but little else. As a rule, the advocates of chemical instruction cannot feel that the subject has been neglected in general science.

The high school girl is well remembered in general science. Her interests are carefully considered in the comparatively large space devoted to the study of household apparatus and arrangement. This is a decidedly progressive step, for there are still schools in which girls are *required* to calculate torques, determine resistances, or laboriously separate manganese from cobalt in solution. And echo always answers "Why?" Like every good teacher, general science has boldly invaded the home and attempted to interest father and mother in the work of the school

—a most proper thing to do. It is interesting to note that the home's chief industry, preparation of food, comes next in the amount of consideration.

Several explanations may be offered as to why the space devoted to plant and animal life are so unequal. This difference is found in all of the texts. The more numerous examples of plants of simple structure, the large number of useful domestic plants, the fact that forty pages were given to plant reproduction and but three to animal reproduction, these and other facts to be deducted from Table 1 may account for the inequality.

It appears that the modern man is ceasing to look at the stars. Only five of the texts included any astronomy in their subject matter. The decline of astronomy as a topic of general study is an unfortunate fact, and it remains for some spirit of Renaissance to revive this science. Are our curricula so like the amoeba, that to expand in one direction they must necessarily contract in another? Shall the most ancient of sciences be discarded from our mass of general information? Shall its broadening influence be limited to specialists who narrow their fields of study to this particular science? I plead for more earnest effort in the diffusion of elementary astronomical knowledge..

In disparagement of its content, general science has been referred to as "grease spot" science. This slur seems to be unfounded, as the topic of textiles, which includes all tests and treatment thereof, has only a limited space assigned to it. In this I think an opportunity for interesting and practical work has been lost—testing, dyeing, cleaning, bleaching and blueing are processes which are neither too technical nor too complicated for elementary experiment. Four of the texts omit this topic entirely.

Three of the authors felt constrained to philosophize on "Man's Relation to Nature." The few pages thus devoted contained the germs of sermons, ingredients of preachments, laborious efforts at inspiration. I was not much impressed with these expressions; it was as if the author feared he had failed to arouse the proper sentiments with his previous instructions, and felt under the necessity to exhort a little. If the earnest study of Nature's great laws cannot stimulate noble thoughts, a little additional philosophy set in cold type will not do it. If the pupil has not indirectly sensed his own participation in the great plan of Nature, telling him will not help. It is an insult to the abilities of a cat to try to *show* him a piece of fragrant fish.

The area of unclassified matter was determined by difference,

and represents blank pages and portions thereof, an accumulation of fractional parts of pages devoted to topics otherwise counted, and the paragraphic treatment of isolated topics to which less than a page was given. To have included all such would have required analytical data "carried out to further decimal places."

Do these texts strictly conform to type as illustrated in Table 2? Of course not—no more than any other ten creations of Nature would. Table 3 (pages 542 and 543) shows graphically their individual differences, and answers many questions.

Is general science a hodge-podge, a disordered collection of scientific material? No, on the contrary, the descent of the average percentage line from subject to subject is fairly regular.

Do the authors of general science texts have hobbies, and give special attention to their favorite subjects? Yes, they do—in eight out of the ten texts some one topic is excessively treated. No text leads in as many as three topics, only four texts lead in two topics, and of the two texts which fail to lead, each occupies a second place under some heading. In seven of the twelve major topics, the excess of some one text is very marked, and these facts plainly show that up to the present time the presentation of subject matter in general science is in no sense standardized. The average percentage of each topic might be considered as representing the composite judgment of the ten authors, but whether a text so written would be ideal is another matter. None of the ten texts show much conformity to this average—book No. 2 is nearest to type, and book No. 1 the widest in its variations.

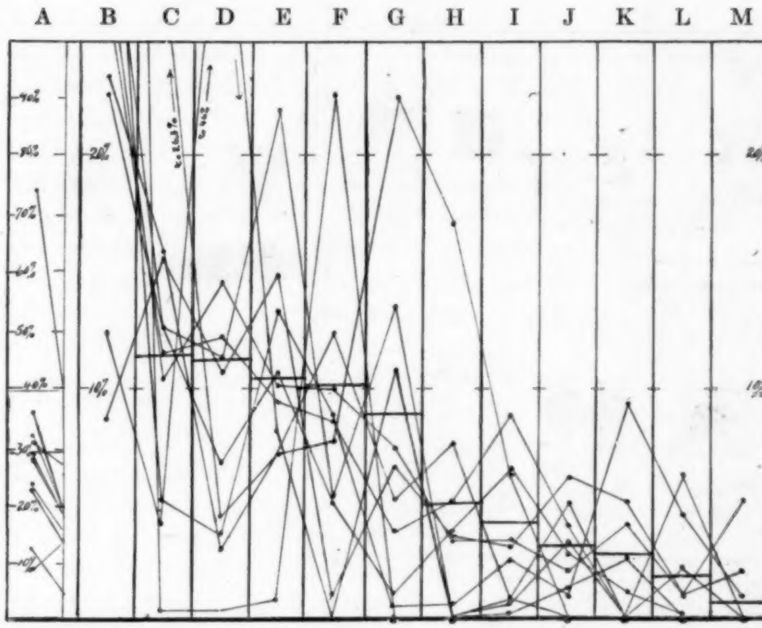
Is general science orderly in its arrangement? Does it lead from topic to topic in logical and connected steps? In general, yes, but each text has its own system—its table of contents displays an outline, in many cases most admirably organized—but no two are alike. No Fresenius has yet arisen to establish a scheme—no Linnaeus has yet arranged general science into family groups. This, I believe, must come in time; a better standardization must precede the universal recognition which will some day be demanded from college entrance boards.

Are the lines of "special science" obliterated? No, for in the new era, marks of the old divisions, like ancient shore lines, may be plainly discerned. It has been impossible to pulverize many hard lumps of "specialized science," especially in physics. Twenty or thirty successive pages on a single topic are not uncommon, and while the effort has been made to make the new science gen-

Physics Scale ¼		Physics		Physiology		Physiography		Plant Life		Chemistry		Meteorology		Household		Foods		Animal Life		Astronomy		Textiles		Economics	
Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%	Book No.	%
1	73.5			6	26.3	5	46.0	4	22.0	1	22.6	9	22.5	9	17.1	7	8.8	10	6.2	3	9.3	7	6.2	10	5.1
3	36.2			9	15.9	2	14.5	10	14.2	6	12.4	4	13.7	6	7.6	8	6.5	6	5.0	10	5.1	3	4.7	2	2.0
8	31.9			10	15.7	7	12.2	3	13.5	2	9.8	5	10.8	7	5.1	9	6.3	7	4.1	2	4.1	6	2.2	3	1.0
6	30.6			8	12.6	4	11.3	8	10.7	3	8.8	2	7.5	8	3.8	2	3.4	4	3.3	5	2.6	10	1.0	9	0.0
2	28.8			4	12.6	10	10.6	2	10.2	7	8.5	10	6.6	10	3.6	10	3.0	8	2.9	8	1.1	2	1.0	8	0.0
7	28.7			7	11.5	8	6.8	7	9.4	9	7.7	6	5.2	2	3.4	3	2.6	2	2.0	1	0.0	8	0.5	7	0.0
9	23.4	9	23.4	2	10.5	6	4.5	5	8.3	4	5.3	7	3.6	3	0.5	1	0.9	5	1.3	4	0.0	1	0.0	6	0.0
4	22.6	4	22.6	3	5.2	3	3.6	9	7.2	8	5.2	8	1.1	5	0.0	6	0.9	3	1.0	6	0.0	4	0.0	5	0.0
5	12.3	5	12.3	5	4.1	9	3.1	6	7.2	10	1.0	3	0.5	4	0.0	4	0.7	9	0.0	7	0.0	5	0.0	4	0.0
10	8.7	10	8.7	1	0.4	1	0.4	1	0.9	5	0.0	1	0.0	1	0.0	5	0.3	1	0.0	9	0.0	9	0.0	1	0.0
												AVERAGES													
	29.6		29.6		11.5		11.3		10.4		8.1		7.1		4.1		3.3		2.6		2.2		1.6		0.8
A		B		C		D		E		F		G		H		I		J		K		L		M	

TABLE 3.

The letters under the vertical columns give the data from which the graphs in the corresponding columns on page 543 were platted.



eral in fact as well as in name, yet there are many places where a browsing reader, covering a dozen pages, would think that he had picked up a physics, physiology, or physiography textbook.

This is not surprising. The very "horizontal stratification" of which there is so much criticism is not a purely arbitrary arrangement. It has evolved through the experience and judgment of generations of teachers; there is a certain cohesion about each group which is at least apparent to one who has completed a year's study therein. It has certainly been easier, from a laboratory standpoint, to demonstrate and experiment with the same articles of equipment over a term of months—not generating gas today and hunting bugs tomorrow—not bringing the kick of a compass and that of a mule too close together in the search for practical knowledge. A change from a "horizontal" stratification to that of a "vertical" could not be in the nature of a volcanic upheaval; the new science would be at once branded as a fad. Whether a text in general science written ten years from now will show any signs of the present divisions is purely a matter of surmise.

IV. Method of Treatment in General Science Texts.

Illustrations. As will be seen by Table 4, with one exception the area devoted to illustrations is generous. In preparing this

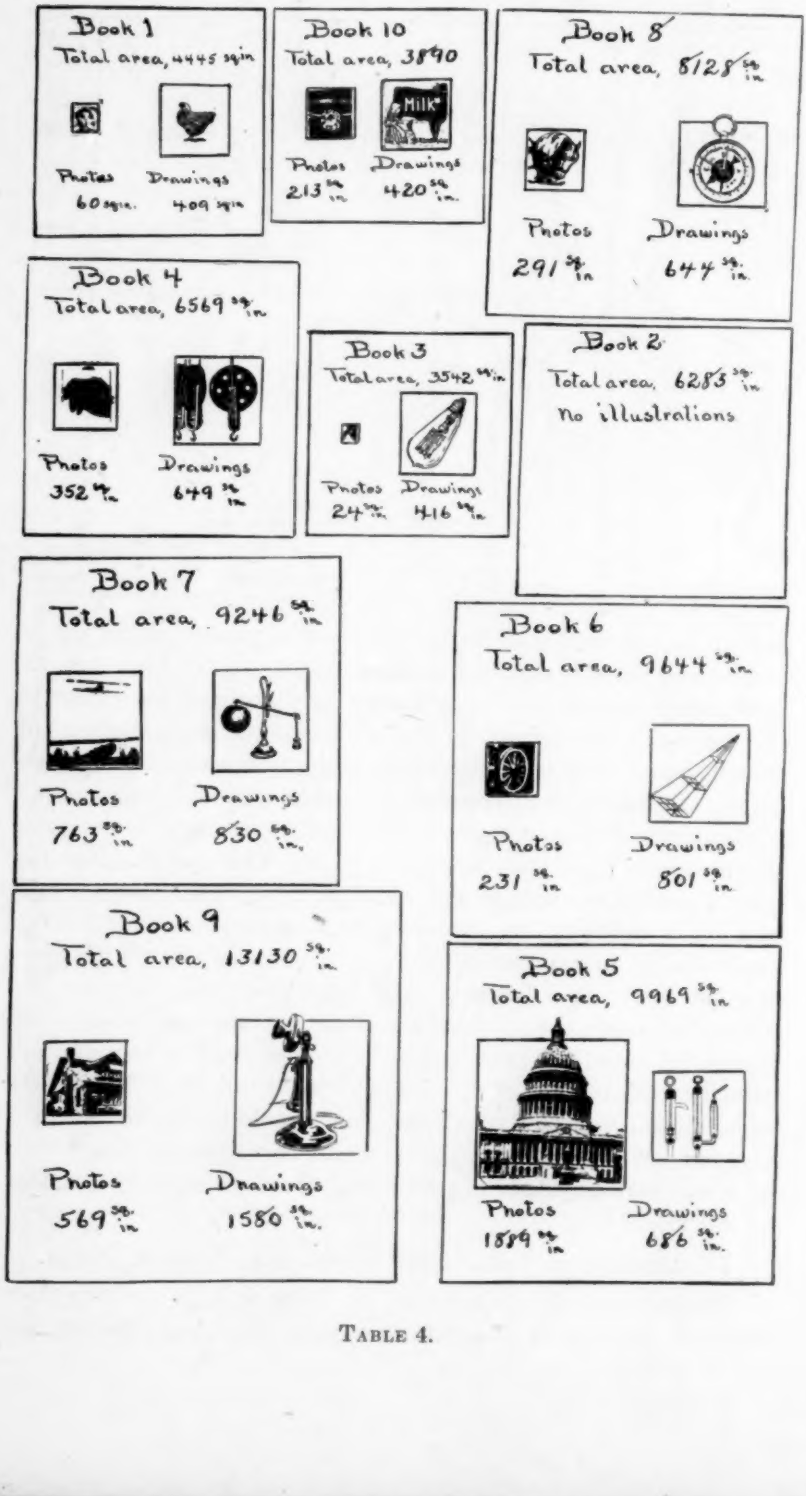

Book 1
Total area, 4445 sq. in.
Photos 60 sq. in.
Drawings 409 sq. in.
Book 10
Total area, 3890
Milk
Photos 213 sq. in.
Drawings 420 sq. in.
Book 8
Total area, 8128 sq. in.
Photos 291 sq. in.
Drawings 644 sq. in.
Book 4
Total area, 6569 sq. in.
Photos 352 sq. in.
Drawings 649 sq. in.
Book 3
Total area, 3542 sq. in.
Photos 24 sq. in.
Drawings 416 sq. in.
Book 2
Total area, 6283 sq. in.
no illustrations
Book 7
Total area, 9246 sq. in.
Photos 763 sq. in.
Drawings 830 sq. in.
Book 6
Total area, 9644 sq. in.
Photos 231 sq. in.
Drawings 801 sq. in.
Book 9
Total area, 13130 sq. in.
Photos 569 sq. in.
Drawings 1580 sq. in.
Book 5
Total area, 9969 sq. in.
Photos 1889 sq. in.
Drawings 686 sq. in.

TABLE 4.

table, the area of the printed page was ascertained, multiplied by the total pages, and the area of the blanks at ends of chapters deducted. The dimensions of each illustration were measured to the nearest eighth of an inch, and properly computed. Areas of photographs and drawings were determined separately, since it is a question in the minds of some as to which type of illustration is most instructive. The area of drawings exceeds that of photographs in all texts except one, but in only two texts are they greatly in excess. There seems to be a fairly uniform proportion in their relation to each other, and but little preference as to their value for instruction.

As to the *style* and *adaptability* of the various texts, that is a subject for the critic, and not for an analyst, such as I have considered myself in this article. Needless to say, there are some places where indefinite rhetoric carries the author over a hard place—where a parrot and a child might use similar methods of mastery—where the statement, "This little do-ey hitches onto that thingumajig," is as clear a concept as the printed text. Some of the most familiar things of everyday life just cannot be simply explained. But on the other hand, there is page after page of inspiring information, practical, interesting, close to life! "The very richness of the field is embarrassing," and less hindered by convention or precedent than any other line of scientific writing. The authors of these texts have indeed gone far to popularize the technical, and to dignify the commonplace. A book that can explain the wireless and talk about dish-rags has indeed a broad appeal.

There are a few errors and an absurdity or two in these 3,610 pages I have studied, but it is not intended to record them here. The spirit lurking in the whole "ten-inch shelf of science" is a simple question directed to the science teachers of the future: "*If a son ask bread of any man, will he give him a stone?*"

COURSES IN SECONDARY AGRICULTURE FOR SOUTHERN SCHOOLS.

To meet the demand for a more uniform standard in agricultural instruction in the secondary schools of the South, the States Relations Service, U. S. Department of Agriculture, has issued a fifty-three page bulletin on this subject. The bulletin, Professional Paper No. 521, covers work in agriculture for the first two years of a four-year course. The aim is to furnish to the teacher a working syllabus readily adaptable to local agricultural conditions.

This bulletin will be supplied to teachers and educators only, without charge, as long as the Department's supply for free distribution lasts.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,

Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

511. *Proposed by Daniel Kreth, Wellman, Iowa.*

In what time would a debt be extinguished by paying the annual interest at 6% if interest be allowed on the payments at the same rate?

I. Solution by De Witt T. Weaver, Middletown, Va.

Let x = the required number of years. Then $x-1$ = number of years the first payment is on interest. The number of years that the various payments bear interest form an arithmetical progression of which the first term is $x-1$, the last term zero, the number of terms, x, and the common difference, -1. The interest on one payment at 6% for a number of years equal to the sum of this series is equal to the total interest allowed on interest payments, which, according to the problem, is the original debt.

Let \$100 = the debt. The interest on *\$6* for one year at 6% is 36 cents.

$$.36\,[(x-1)+(x-2)+\cdot\cdot\cdot\cdot+3+2+1+0] = 100.$$

$$.36\,\frac{x^2-x}{2} = 100, \qquad (1)$$

whence

$$x = 24.+$$

Since x is an integer and is more than 24 then $x = 25$. In 25 years the interest on the payments amounts to \$108. In 24 years it amounts to \$99.36 In both cases the time is reckoned from the time the money is put on interest.

Remarks by the editor.

The exact time may be obtained by finding time required for \$144 (24 payments) to earn \$0.64 (\$100 − \$99.36) at 6%, thus completely liquidating the debt. This result, 27 days, added to 24 years makes the complete time required, namely, 24 years and 27 days.

Attention is called to the commendable care used by Mr. Weaver in regarding x as an integer, which is an assumption upon which the formula (sum of the series) used in equation (1) is derived. In common practice, equation (1) is solved for the approximately exact value of x, namely, 24·976 · · · and this value is used as the correct result. In this particular case the method produces no appreciable error, for 24.076 years = 24 years and 27 days. If, however, the rate of interest be 5% instead of 6% the common mistake of considering x non-integral gives rise to an error of one day in the time.

To derive a formula which would cover the case and be mathematically exact, and rigorous, we would proceed as follows:

Let $n = n' + e$ be the exact time in years, where n' is an integer and $0 \leq e < 1$. Let i be the interest paid in every year on the unit principal. Then

$$1 = i^2[(n-1)+(n-2)+ \cdot \cdot \cdot \cdot \cdot +(2+e)+(1+e)+e]$$
$$= i^2[(n'+e-1)+(n'+e-2)+ \cdot \cdot \cdot \cdot +(1+e)+e]$$
$$= i^2[(n'-1)+(n'-2)+ \cdot \cdot \cdot +2+1+(n'-1)e]$$
$$= i^2[\frac{n'(n'-1)}{2} +e(n'-1)].$$

$\therefore n'^2 + (2e-1)n' - 2e - \frac{2}{i^2} = 0,$ whence

$$n' = \frac{1-2e}{2} + \frac{1}{2i}\sqrt{i^2+8}.$$

By giving e the limiting values, zero and unity, we obtain

$$-\frac{1}{2} + \frac{1}{2i}\sqrt{9i^2+8} < n' < \frac{1}{2} + \frac{1}{2i}\sqrt{i^2+8},$$

which determines the integral value (positive) of n'. For example, in the problem 511, $i = .06$, and

$$-\frac{1}{2} + \frac{1}{.12}\sqrt{8.0324} < n' < \frac{1}{2} + \frac{1}{.12}\sqrt{8.0036},$$

or

$$23.1 < n' < 24.05, \text{ whence } n' = 24.$$

512. *Proposed by N. P. Pandya, Khatri Pole, Bajwada, Baroda, India.*

The logarithms (Briggian) of two numbers differ by 1.4238 and the numbers themselves by 3856. Find the numbers.

I. *Solution by Henry Hitchcock, Galesburg, Ill. and R. M. Mathews, Riverside, Cal.*

Let x and y be the required numbers.

By hyp. $x-y=3856$ (1)

and $\log x - \log y = \log x/y = 1.4238.$

From log table, $x/y = 26.534.$

Hence, $x = 26.534\, y.$

Substituting in (1), $25.534\, y = 3856.$

Hence, $y = 151.015.$

Substituting in (1), $x = 4007.015.$

II. *Solution by R. T. McGregor, Nord, Cal.*

Let $n + \frac{3856}{2}$ and $n - \frac{3856}{2}$ denote the numbers. Then from the formula, $\log_e(n+a) - \log_e(n-a) = 2\left(\frac{a}{n} + \frac{a^3}{3n^3} \cdot \cdot \cdot\right)$ we have, where $a = 1928$, $\log_e(n+1928) - \log_e\left(n-1928 = 2\,(1928/n + \frac{(1928)^3}{3n^3} \cdot \cdot \cdot\right) = 1.4238 \log_e 10.$

From this equation we find that n is 2079. Hence the numbers are 4007 and 151.

III. *Solution by Felix S. Hales, Cleveland, Ohio.*

Let x = one number and $3856 + x$ = other number

Then $\frac{3856+x}{x} = (10)^{1.4328} = \log^{-1} 1.4328,$

or $\frac{3856+x}{x} = 26.53.$

$$3856 + x = 26.53x$$
$$25.53\, x = 3856$$
$$x = \frac{3856}{25.53} = 151. \quad = \text{one number.}$$
$$3856 + x = 4007 = \text{other number.}$$

Geometry.

513. *Proposed by Murray J. Leventhal, New York City.*

Given a point, a straight line, and a circle, to construct a circle having its center in the given line, passing through the given point, and cutting off on the given circle an arc whose subtending chord is equal to a given line segment.

513. *Solution by M. G. Schucker, Pittsburgh, Pa.*

Let P be the given point, MN the given line, ML the given line segment, and O center of the given circle. From P let fall a perpendicular PD on MN and produce it making $D2 = PD$. Describe any circle through P and 2 and intersecting circle O in A and B. Draw AB produced to meet P2 produced in R and further produce AR through R to B′ making $RB' = BR$. On AB′ construct a semi-circle and erect a perpendicular to AB′ at R intersecting semicircumference at S. Lay off on RA, $RL' = \frac{ML.}{2}$ Draw SL′ and produce it through L′ to T making $L'T = \frac{ML.}{2}$ From R as a center with a radius equal to ST draw an arc intersecting O in E and G. Draw ER and GR intersecting O in F and H, respectively. A circle through P, 2, and F, and one through P, 2, and H answer the required conditions.

$$AR \cdot BR = PR \cdot 2R;\ AR \times B'R = \overline{RS}^2;\ SL' = \sqrt{\overline{RS}^2 + \frac{\overline{LM}^2}{4}}$$

$$RE = SL' + L'T = \frac{ML}{2} + \sqrt{\overline{RS}^2 + \frac{\overline{LM}^2}{4}}, \text{ by substitution.}$$

Transposing and squaring $RE^2 - \overline{ML} \cdot \overline{RE} + \frac{\overline{ML}^2}{4} = \overline{RS}^2 + \frac{\overline{LM}^2}{4}$

Hence $\overline{RE}^2 - \overline{ML} \cdot \overline{RE} = \overline{RS}^2 = \overline{AR} \cdot \overline{BR}$

$RE\ (RE - ML) = \overline{AR} \cdot \overline{BR}$

but $RE \cdot RF = AR \cdot BR$. $\therefore RF = RE - ML$, $\therefore EF = ML$

The circle through F, P, and 2 is intersected at E′ by FR. $\therefore E'R \cdot FR = P2 \cdot 2R$. But $P2 \cdot 2R = AR \cdot BR = RE \cdot FR$. $\therefore E'R \cdot FR = ER \cdot FR$. $\therefore$ E′ coincides with E and circle through P, 2 and F passes through E and is a required circle. Only one solution, if MN is tangent to O; none if MN is $\perp$ OP.

514. *Proposed by Yeh-Chi Sun, Peking, China.*

Having given the lengths of the three angle bisectors of a triangle, required to construct the triangle.

No solutions have been received for this problem.—Editor.

515. *Proposed by L. E. Lunn, Heron Lake, Minn.*

Prove the following theorem: The planes perpendicular to the faces of a trihedral angle and intersecting those faces along the bisectors of the face angles are coaxial.

Solution by M. G. Schucker, Pittsburgh, Pa.

Since each dihedral angle of a trihedral angle V-ABC is less than a straight dihedral angle, any two of the planes through the bisectors of the face angles perpendicular to the faces of the trihedral intersect in a line VO. These planes are loci of points equidistant from the respective edges of the trihedral which are the sides of the respective face angles bisected. Hence, VO is a line whose points are equidistant from the edges of the trihedral. Therefore, the third plane also passes through VO and the planes are coaxial.

A Request.

We respectfully request that all contributors read and heed the following rules:

1. Introduce each solution submitted as follows: 999. Solution by (*Your name and address*). It is not necessary to copy the words of the problem. The number is sufficient.
2. Write only on one side of the paper.
3. If two or more short solutions are written on the same page, leave ample space between problems and don't fail to observe Rule 1.
4. Do not make solution dependent on a submitted figure, e. g., do not write "line AB" with no previous verbal definition of A and B, expecting a reader to find the line and points on a figure. It is not always convenient to publish the figure.
5. Where a figure is necessary draw the same accurately and to scale on a separate sheet of paper in jet black or India ink.
6. Introduce each problem proposed as follows: Proposed by (*Your name and address*). When more than one proposed problem is written on a page, leave ample space between problems that they may be clipped.

CREDIT FOR SOLUTIONS.

506. R. Starrett, Daniel Kreth. (2)
511. DeWitt T. Weaver, Daniel Kreth, 3 incorrect solutions. (5)
512. Charles H. Bartlett, William B. Campbell, R. S. Gatherum, Felix S. Hales (2), Henry Hitchcock, Murray J. Leventhal, R. T. McGregor, R. M. Mathews, Garson Prenner, Fannie C. Reisler, M. G. Schucker, H. H. Seidell, DeWitt T. Weaver. (14)
513. M. G. Schucker.
515. R. M. Mathews, M. G. Schucker. (2)

24 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

526. *Proposed by R. T. McGregor, Nord, Cal.*

Show that every cube number must be of the form $9n$ or $9n \pm 1$.

527. *Proposed by the editor.*

A man arranges to buy a house for \$5,000 paying \$1,000 down and the remainder in equal monthly installments of \$50. It is agreed that each installment is to pay the accrued interest and the remainder of the installment is to apply on the principal. How many payments will be required to extinguish the debt, with interest at 6%, compounded annually?

Geometry.

528. *Proposed by Daniel Kreth, Wellman, Ia.*

Construct a triangle, having given one angle, a side opposite to it, and the sum of the other two sides.

529. *Proposed by R. T. McGregor, Nord, Cal.*

The circle, whose diameter is the third diagonal of a quadrilateral inscribed in another circle, cuts the latter orthogonally.

Trigonometry.

530. *Proposed by N. P. Pandya, Sojitra, India.*

If $\sin^4\theta + \sec^2\theta + \tan^2\theta = \cos^2\theta + \operatorname{cosec}^2\theta$, find $\sin 2\theta + \cos 2\theta$.

SCIENCE IN THE HIGH SCHOOL OF TOMORROW.

At the last meeting (December, 1916) of the Central Association of Science and Mathematics Teachers, Dr. David Snedden, of Columbia University, delivered an address upon "The High School of Tomorrow." As a result of this address, a committee was appointed to consider the question, "Science in the High School of Tomorrow."

The membership of this committee was announced late in February, 1917, the following being appointed:

Franklin T. Jones (Physics), Chairman, University School, Cleveland, Ohio.

H. N. Goddard (Agriculture), State Inspector of High Schools, Madison, Wis.

H. B. Shinn (Biology), Carl Schurz High School, Chicago, Ill.

B. J. Rivett (Chemistry), Northwestern High School, Detroit, Mich.

J. M. Large (Earth Science), Township High School, Joliet, Ill.

Minna C. Denton (Home Economics), Ohio State University, Columbus, Ohio.

Raleigh Schorling (Mathematics), University High School, Chicago, Ill.

This committee, after collecting some material on the assigned subject, met on April 12 and 14, in Chicago. The magnitude of the problem confronting it was immediately apparent. It was clear that no real recommendations that would be likely to carry weight could be made at the present time—that the *ultimate* course in science in the high school of tomorrow could not be at present predicted—but the committee was determined to make a start by proposing to each other and to others some outline of an *immediate* course in science for the high school of the immediate tomorrow.

For the present, therefore, it is recommended (1) that the study of *Chemistry* and *Physics*, as specialized sciences, should remain in the third and fourth years of the high school course (11th and 12th grades); (2) that, in the second year of the high school course, *biological science* should be taught (no recommendation is now made as to the minimum number of hours per week); (3) that, preceding the second year, an introductory science clearly should be taught, but its character, title, length and subject matter are still in doubt.

In this situation the committee finds itself facing a series of problems in the solution of which the assistance of readers of School Science and Mathematics and all others interested is earnestly desired. Some of the problems are the following:

(1) To seek a unified course in science in contrast to a train of specialized sciences, meaning a course in science extending over four or more years.

(2) To seek a unifying principle for such a course.

(3) To classify the varieties of schools for which a unified science course is desired.

(4) To propose a sequence for each type of school.

(5) To attempt the formulation of an aim, or aims, in the teaching of a unified science course.

(6) To seek a minimum list of topics for mastery in each subject.

(7) To seek a minimum list of topics from each specialized science for incorporation in the course in introductory science (such specialized sciences are agriculture, animal husbandry, astronomy, botany, biology, chemistry, cooking, domestic science, earth science, geology, household management, mathematics, physiography, physiology, physics, sanitation, zoology, etc.).

(8) To seek the establishment of a clearing house for such minima.

The committee desires to cooperate with other committees working on courses of study, content, of course, or similar line. Individuals are invited to propose other problems, and give their assistance in the solution of the problems stated above.

Please write to any member of the committee. As far as possible, all contributions will be publicly acknowledged.

Contributions have already been received from Boise, Idaho; Rochester, N. Y.; Muskegon, Mich.; Springfield, Mass., Boston, Mass., and from a number of individuals whom we expect to mention later.

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your second term or final examination papers now.*

Questions and Problems for Solution.

270. *Proposed by William T. Reed, Woodlawn, Pa.*

Will a boat sunk in midocean ever reach the bottom? If it does reach the bottom, what principles of physics are involved? If it does not reach the bottom, state why.

271. *Proposed by Niel Beardsley, Bloomington, Ill.*

Given a single movable pulley. One rope is fastened to the ceiling. A man stands on the pulley and pulls upward on the other rope. How much must he pull to just balance? Can he lift himself?

272. *Proposed by Ross A. Baker, Minneapolis, Minn.*

What volume of H_2SO_4 (sp. gr. = 1.84) and what weight of NaCl would be required to produce the HCl present in 8 kgm. of a 3% solution of HCl?

273. *Submitted by Philo F. Hammond, University of Alberta, Edmonton South.*

The Extension Department of this University received a request from a secondary school in Alberta Province for a method of determining the constant, k, in the formula, $F = k\dfrac{m_1 m_2}{d^2}$, as applied to universal gravitation. The Ontario High School physics gave 0,000,000,064, 8 dynes as the attractions between two small spheres, each weighing one gram, if placed one centimeter apart. How was this result obtained?

Please answer question numbered 274 in the list that follows.

Examination Papers.

PRINCETON, COMPREHENSIVE CHEMISTRY, OCTOBER, 1916.

PART 1.

(*Answer all questions in Part 1.*)

1. State and exemplify –
   a. The law of definite proportions.
   b. The law of multiple proportions.
   c. Boyle's law.
2. a. Write the names and formulae of five acids containing chlorine, together with their sodium salts.
   b. Calculate the percentage of oxygen in Glauber's salt ($Na_2SO_4 . 10H_2O$).
3. a. Give two methods for the preparation of hydrogen—one involving the use of an acid and the other red-hot iron. Write the chemical equations involved.
   b. State the physical and chemical properties of hydrogen.
   c. What is the difference between *hydrogen gas* and *hydrogen-ion?*

274. How much carbon dioxide by weight and by volume, at 21° and 755 mm., could be obtained by treating 8 grams of pure calcium carbonate with an excess of hydrochloric acid? (Note.—A liter of carbon dioxide at 0°C. and 760 mm. weighs 1.977 g.)

5. Write chemical equations representing—
   a. The combustion of a hydro-carbon.
   b. The preparation of ammonia.

c. The preparation of nitric acid.
d. The interaction of aluminium hydroxide and nitric acid.
e. The formation of ozone.

PART 2—SUPPLEMENTARY REQUIREMENTS.

Group A.

(*Answer two questions from this group.*)

6. How is aluminium obtained on a commercial scale? Give diagram of apparatus employed.
7. a. Give a good method for the preparation of hydrogen sulphide, including the chemical equation involved.
b. What are the physical and chemical properties of hydrogen sulphide?
c. For what is the compound used?
8. Tell how you would proceed to prepare pure potassium nitrate from potassium chloride.
9. Describe the various allotropic forms of carbon.

Group B.

(*Answer one question from this group.*)

10. a. State Avogadro's hypothesis.
b. Explain why the formula for oxygen gas is represented by O_2 rather than O.
c. Why is O_3 used as the formula for ozone?
11. A compound by analysis gave 27.06 per cent sodium, 16.47 per cent nitrogen, and 56.47 per cent oxygen. Calculate its simplest formula.

Group C.

(*Answer two questions from this group*).

12. How would you identify by chemical tests—
a. Carbon dioxide.
b. Nitric acid.
c. Silver nitrate.
d. Sodium carbonate.
e. Copper sulphate?
13. a. Name some natural fats and oils.
b. What can you say about their composition?
c. What is soap, and how is it prepared?
d. What are proteins?
e. What are carbohydrates?
14. a. What is vinegar? How is it made?
b. What is cream of tartar? What is its function in baking?
c. What is yeast? What is its function in bread-making?
15. a. Discuss the relation of oxygen and carbon to plants and animals.
b. Tell what you can about the relation of nitrogen to life.

[Ca = 40, C = 12, Cl = 35.5, S = 32, Na = 23, N = 14.]

DARTMOUTH COLLEGE, ZOOLOGY, SEPTEMBER, 1916.

ENTRANCE EXAMINATION.

1. Describe the life history of an amoeba, or of some other unicellular animal, under the following heads: (*a*) structure; (*b*) movements; (*c*) nutrition; (*d*) reproduction; (*e*) where it lives; (*f*) what good, or harm, it may do to man.
2. What is a parasite? Describe the life history of some parasite.
3. Describe the structure of two different kinds of animals you have studied (not including a unicellular one), and point out in what respects they agree, and in what respects they differ.
4. What is blood? How and why does it circulate? What are the principal things it carries? Where are they taken up and where delivered?
5. What is a nerve? What purpose does it serve? What is a muscle? How are muscles arranged in the walls of the stomach and intestines? What purpose do they serve there?
6. What insects are serviceable to man? In what ways?

7. Describe how a cell divides.
8. What is evolution? Explain Darwin's theory of natural selection.
9. Describe a case of mimicry; of protective resemblance.
10. Describe how an egg is fertilized.

(Note.—The laboratory note-book, containing the complete record of the student's laboratory or fieldwork, signed by the student and his instructor, must be submitted to the college officials at the time of the examination, or within a reasonable period thereafter.)

Solutions and Answers.

249. *Proposed by John C. Packard, Brookline, Mass.*

What effect, if any, do high altitudes have on the power of a steam engine?

Answer by R. S. Hawley, M. E., Colorado School of Mines, Golden, Colo.

The answer to this involves several points. First, for the same initial gage pressure in the cylinder, an engine running noncondensing will have a greater range of expansion at an altitude than at sea level. For noncondensing engines, therefore, there is a tendency for increased horse power as the altitude increases. For condensing operation the effect is just reverse. There is less to be gained by using the condenser at an altitude because there is less reduction in back pressure and therefore less gain in mean effective pressure and horse power.

244. *Also answered by P. C. Hyde, Newark Academy, Newark, N. J.*

[This problem will be discussed again later.]

255. *Proposed by Ross Allen Baker, University of Minnesota.*
(*From a list for students in general chemistry.*)

Suppose 100cc. of H_2 were mixed thoroughly with 500cc. of Cl_2 and exploded, and the product cooled to the original temperature. What would be the total volume and of what would it consist?

Solved by Annie Cloyd, Sewickley, Pa.

H and Cl unite in equal volumes and the volume of product is double that of volumes uniting, as shown by following equation:

$H_2 + Cl_2 = 2HCl.$

$\therefore$ when the mixture is exploded 100cc. of H unites with 100 cc. of Cl making 200 cc. of HCl. $\therefore$ there will be 600cc. of gas in the tube, 200cc. of HCl and 400cc. of Cl, or, if the original temperature was low enough to condense all the HCl vapor there would only be 400cc. of Cl left.

256. *From an examination of Carnegie Institute of Technology.*

What power is developed by a force of 300 pounds moving with a velocity of 10 feet per second?

Solution by R. T. McGregor, Nord, Cal.

Since 1 H. P. equals 550 lb. moving 1 ft. per sec. we have $\frac{300 \times 10}{550} = 5\frac{5}{11}$ H. P.

257. A body, mass 100 grains, is heated to the temperature of steam, and is then dropped into a calorimeter containing 100 grams of water at 15 degrees C. The temperature rises to 25 degrees C. If the water equivalent to the calorimeter is 10 grams, what is the specific heat of the test piece?

Solution by Annie Cloyd.

Heat lost = heat gained.

Metal lost 100 $(100-25)x$ calories.

H_2O and calorimeter gained $(100+10)$ $(25-16)$ calories.

$\therefore 7500x = 1{,}100,$

$\therefore x = .146 +$ sp. heat. of test piece.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

Is There a Subelectron?

The question often arises as to whether or not electricity is atomic in structure, or, to put it another way, whether the electron is the unit of electricity in some such way as the atom is the smallest unit into which any given element may be divided. The answer to this question, in so far as an answer can be made, based on the information which physicists have been able to obtain, was given by Professor Millikan of the University of Chicago in the December number of the *Physical Review*, in which he states that there has appeared up to the present time no evidence for the existence of a subelectron.

Although the idea of an elementary electric charge was first suggested in 1833 by Faraday's discoveries in electrolysis, it has not been until recent years that much progress has been made in the isolation and study of the ionic charge. The investigations carried on in the Cavendish Laboratory about 1900 brought to light the existence of a body, Sir J. J. Thomson's corpuscle, now called the electron, of which the value of e/m was 1/1,830 of that found on the hydrogen ion of electrolysis. None of the methods, however, were capable of yielding anything more than a mean value of the charge. It was not until 1909 that direct measurements of the ionic charge could be realized. At that time Professor Millikan accomplished this by isolating in a vertical electric field, individually charged water droplets and determining the amount of electricity carried by each drop by measuring the speed under gravity and the speed under the combined action of the field and gravity.

The proof that all electric charges, whether on ions or on large bodies, insulators and conductors, are simply an assemblage of elementary electrical specks or atoms, all of which are exactly alike, rests upon the following discoveries: (1) that the ionic charges obtained by capturing ions from gases on any kind of a body are all exactly alike or else small exact multiples of a definite charge; (2) that the static charges residing on all kinds of bodies, from insulators up to conductors, and put there by frictional or other processes, are always exact multiples of this smallest ionic charge; (3) that the direct detachment of negative electrons from the drop by the incidence of X-rays upon it produces the same change in charge as the capture of an ion. The evidence is as follows:

So long as a charged droplet remains constant in shape and size, the change in its speed in a given electrical field, caused by the capture by the drop of one or more ions is a measure of the charge carried by the captured ion or ions. These changes in speed were found to be all exactly alike or else exact small multiples.

Again, if the total speed produced in the charged drop by throwing on the given electrical field is found to be always an exact multiple of the smallest change in speed produced by the capture of ions, then the original charge, produced by friction or otherwise, must be built up out of these smaller ionic charges. This relation was found to be in every case exactly fulfilled.

Finally, if the change in speed produced by letting X-rays or ultraviolet light fall upon the particle and detach negative corpuscles from it is the same as that produced by the capture of ions, then the ionic charge must be the same as the charge carried by the corpuscle or beta particle.

Very conclusive evidence on all of these points was found by Professor Millikan in the winter of 1909 and 1910. However, Professor Ehrenhaft of Vienna in the following fall, and later, brought forth results which he regarded as indicating the existence of charges smaller than that which had been assiged to the electron. The paper to which reference has been made deals with this work, and shows this evidence for a subelectron to be ungrounded. Professor Millikan has recently made still more complete studies of the ionic charge, varying through wide limits the size of the drops and the nature and density of both the gas and the drops. The new determination of e is practically identical with the original at 4.774×10^{-10} electrostatic units.

While it would not be in keeping, as Professor Millikan states, either with the spirit or with the method of modern science to make any dogmatic assertion about the existence or nonexistence of a subelectron, he can assert that there has never appeared, to his knowledge, any evidence of its existence.

Bursting of Hot Water Pipes.

It seems to have been a common observation by plumbers that the pipes carrying the hot water from the furnace to the kitchen and bathroom burst from freezing more frequently than do the pipes carrying the cold water. It is said that the ratio of frequency is at least four to one. The "cold water" usually freezes, so as to lessen the flow of water in the pipes or to stop it entirely, but this freezing is seldom accompanied by bursting. The bursting of cold-water pipes is generally expected only when the temperature is very low. That hot-water pipes should burst more readily than pipes carrying cold water might appear anomalous. So runs the introductory paragraph of an article[1] by Professor F. C. Brown, in which he describes a series of experiments undertaken to verify the observations of the plumbers and to ascertain the physical explanation.

Ordinary tap water, freshly drawn, was placed in test tubes to simulate the conditions in the cold-water pipes and the same tap water, shortly after being boiled, was placed in like tubes to simulate the conditions in the hot-water pipes. The tubes were placed alternately in racks and set in the open at a time when the temperature was at varying degrees below zero. In every test the tubes of boiled water burst first; out of fifty pairs, forty-four burst, while but four of those filled with unboiled water were broken. The observations of the plumbers having been verified, the next step was to obtain the explanation.

It was found that the ice formed from the boiled water was quite clear and solid and that the water invariably undercooled several degrees before freezing began. Unboiled water, however, always began freezing at zero, and the ice was full of air bubbles and appeared quite slushy, particularly near the central axis of the tube. In fact, the air tended to freeze out toward the middle and the semi-open space acted as a sort of safety valve to relieve the pressure caused by freezing. On the other hand, the undercooling of the air-free water tended to make the center of the tube freeze just as solid as the water near the surface.

In addition, the occluded air tended to make the ice more fluid. There was a greater rise of the ice in the case of the unboiled water, showing that the ice from this water was less viscous than the other, or that the

[1] *Physical Review*, N. S., 8, 500, 1916.

central core was mobile sufficiently long to relieve the pressure. Check experiments performed with water which was saturated with air, after having been boiled, and other tests, confirmed the view that the occluded air in ordinary tap water is responsible for the delay or absence of bursting in the pipes.

A Proposed New Thermometer Scale.

Mr. Alexander McAdie of the Blue Hill Observatory has proposed a new temperature scale in which the zero point is absolute zero and the 1,000° point the temperature of melting ice. Physicists have generally conceded that the Fahrenheit scale has outlived its usefulness, and much has been done to promote the use of the Centigrade scale, attempts having been made to pass a law requiring its use in government publications. Many meteorologists, however, have opposed the introduction of the Centigrade scale on the ground that, even when read to tenths, the scale division is entirely too large for meteorological purposes.

To meet this objection Mr. McAdie suggests a new scale, to be known as the New Absolute, or simply New. Having zero at the zero of the Absolute scale, approximately 491° below freezing on the Fahrenheit and 273° below on the Centigrade, and the 1,000° point at the temperature of freezing, the new scale will afford scale divisions even smaller than the Fahrenheit degree, and will permit of the refinement of reading desired by meteorologists.

Among the other advantages of the new scale is the abolition of the minus sign. In all upper air work temperatures are, as a rule, below freezing. At a height of ten kilometers one has to deal with temperatures as low as or lower than those experienced by Scott in the Antarctic. For example, $-66.0°$ F., $-54.0°$ C., or 218.4° A., is on the New scale 800°. Again, the great distinction between *warm* and *cold*, as experienced in the everyday affairs of life, is plainly marked; thus, temperatures below freezing are below the 1,000° mark; and temperatures above so-called summer heat are above 1,100°.

The arrangement of the new scale would make for clearer conceptions of the magnitude of temperature changes, the scale starting from the temperature of no molecular motion and laying emphasis on the one great physical change of state of water, familiar to all.

Evidences point to a change from the Fahrenheit scale to the Centigrade scale in the near future. As any change will cause considerable temporary inconvenience, it is highly desirable that everything be done to make the scale which is adopted the most satisfactory from all standpoints. It is to be hoped that those who favor the Centigrade scale will not hesitate to change their allegiance to the New scale if it appears that it would in the end prove the more satisfactory.

Emanation Content of Spring Water.

The cause of the variation of the emanation content of spring water has been found by Professor R. R. Ramsey of Indiana University.[1] Having found a variation in Indiana and Ohio springs, he measured, during nine months, the radioactivity of two springs and the flow of one. These measurements showed that the emanation content of the water increased and decreased with the flow. Taken with the fact that the flow of all the springs in the neighborhood varies with the rainfall and that some of the highest values of the emanation content of spring water were obtained from "wet weather" springs a short time after heavy rains, the experiments point to the conclusion that the rain water, in percolating through the soil, dissolves and carries down with it some of the

[1] *Physical Review*, N. S., 7, 284, 1916.

emanation which is continually moving upwards from the depths of the earth to the surface. During dry weather, when the flow is not rapid, a large per cent of the emanation dissolved in the water is transformed into radium A, B, C, and D, before the water issues from the ground. This is in accord with the observation that the amount of emanation which issues from the soil decreases as much as fifty per cent at times after heavy rains.

GENERAL SCIENCE COURSES IN SUMMER SCHOOLS.

At the University of Pittsburgh, Professor W. G. Whitman of the Salem, Mass., Normal School will offer two courses, one covering seventh and eighth grade work and the other ninth grade work. These courses are eight weeks in length.

At the University of California, Professor Percy Rowell of the A to Zed School will offer a course in general science.

At Columbia University, Professor Williams of the Horace Mann School, New York, will offer a course for teachers of general science at the Teachers' College.

At the Illinois State Normal University, Principal W. L. Goble of the Elgin High School will offer a six weeks' course in general science. This course will deal principally with general science for the ninth grade.

At Iowa State College, Professor F. D. Barber of the Illinois State Normal University will offer a six weeks' course in general science, adapted especially to the needs of teachers in the consolidated high schools of Iowa.

University of Nebraska—Prof. Herbert Brownell will give the course.

State Normal School, Peru, Neb.—Prof. B. C. Hendricks will give the course.

State Normal School, Kirksville, Mo.—Prof. W. J. Bray will probably offer a course.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for April; *5548 Kenwood Ave., Chicago; $3.00 per year:* "Discussions of Fluxions: From Berkeley to Woodhouse," Florian Cajori; "Note on Some Applications of a Geometrical Transformation to a Certain System of Spheres," Henry W. Stager; "The Astrolabe," Marcia Latham; "A Useful Principle in Curve Tracing," Arnold Emch.

Geographical Review, for April; *New York City; $4.00 per year, 40 cents a copy:* "Presentation of the David Livingstone Centenary Medal to Colonel Theodore Roosevelt;" "Up the Orinoco to the Land of the Maquiritares" (1 map, 9 photos), Leo E. Miller; "Congestion in Cities" (5 photos), Sidney A. Reeve; "The Date of Oviedo's Map of the Maracaibo Region" (1 map), Rudolph Schuller; "The Geographical Work of Dr. M. A. Veeder (second half)," Ellsworth Huntington; "The Andes of Southern Peru: A Review," Theodore Roosevelt.

Journal of Geography, for May; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "A Classified List of Geographical Material," Mary J. Booth.

Nature-Study Review, for April; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Concerning Wild Ducks and Color Key to the Ducks of the Eastern United States," Elsa G. Allen; "Humming Birds," Louis A. Fuertes; "The Thrush Family," Gilbert H. Trafton; "Our Most Intimate Bird Neighbors," Laura A. L. Turner; "Bird Notes," by several writers; "Bird Work in Ethical Culture School, New York City," Myrtle B. Boice; "Bird Protection," Guy A. Bailey.

Photo-Era, for May; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "The Electric Current in Bird Photography," G. A. Borley; "Filing Negatives and Prints," W. S. Davis; "Photographing on the Firing Line," A. K. Dowson.

Physical Review, for April; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy;* "Natural and Magnetic Rotatory Dispersion in the Infra-red Spectrum," L. R. Ingersoll; "Theoretical Considerations in the Nature of Metallic Resistance, with Especial Regard to the Pressure Effects," P. W. Bridgman; "Tolman's Transformation Equations and the Photo-electric Effect," S. Karrer; "On the Phosphorescence of the Uranyl Salts," Edward L. Nichols and H. L. Howes; "Notes on the Change of Resistance of Certain Substances in Light," T. W. Case; "An Improved High Vacuum Mercury Pump," C. T. Knipp; "Electrode Polarization in Gases," C. A. Skinner; "Critical Examination of the Law of X-Ray Line Spectra," H. S. Uhler.

Popular Astronomy, for May; *Northfield, Minn.; $3.50 per year:* "The Place of the Class R Spectra in the Harvard Sequence," R. H. Curtiss; "The Early History of the Theory of Eccentrics and Epicycles," Noel Sargent; "The Southern Cross," Isolina V. Millas; "A Curious Spectroscopic Double Star," translated by Charles Nevers Holmes; "Solar Eclipse of 1917, June 19, as Visible in the United States," William F. Rigge; "The Enclosed Observing Room," Russell W. Porter; "Determination of the Proper Motion in the System Σ 142," Michael J. Kaplan.

Popular Science Monthly, for April; *New York City; $1.50 per year, 15 cents a copy:* "Why Zeppelins Are Frightful," Carl Dienstbach; "The Terror of the Sea Handling Live Rattlers," A. M. Jurymauss; "War Time Uses of Wood," A. W. Schoyer; "How Points Are Made," Henry A. Gardner; "Winning an Athlete's Laurels," Albert B. Wegener.

School World, for April; *Macmillan & Company, London, Eng.; 7s 6d per year:* "Manual Training in Secondary Schools for Boys," S. Pollitt; "The Place of Geography in Education," B. C. Wallis; "The Place of Textbooks in Science Teaching," G. N. Pingriff; "Measuring the Results of American Education," Peter Sandiford; "The Object and Conduct of Internal Examinations."

Review of Reviews, for April; *New York City; $3.00 per year, 25 cents a copy:* "America's Part in the War," the Editor; "The Allies' Great Advance," Frank H. Simonds; "Rt. Hon. A. J. Balfour," Nicholas Murray Butler; "Joffre and Viviani," Myron T. Herrick; "Mobilizing Our Resources;" "American Farm Problems," Carl Vrooman; "Armies of Food Supply," Hugh J. Hughes; "School Gardens," P. P. Claxton; "America's Great War Loan," C. F. Speare; "Serving the Nation," John Finley; "A Thousand Wooden Ships," W. L. Marvin; "The Supreme Court and the Railroad Brotherhoods," William Z. Ripley.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION MEETING AT PASADENA, APRIL 21, 1917.

The eighteenth regular semiannual meeting of the Southern California Science and Mathematics Association was held in Pasadena Hall, Throop College, at Pasadena, Cal.

The general morning session was called to order at 10 a. m. by the President, Mr. Westcott. About eighty were present.

The program included the following addresses:

"Mental Tests and Their Applications to Mathematical Deficiencies," Grace M. Fernald, Ph. D., State Normal School, Los Angeles.

"Vaccines and Serum Therapy," Dr. Walter V. Brem, Los Angeles.

"What the High School Should Expect in Mathematics from the Elementary School," Dr. Albert Shiels, Superintendent of Schools, Los Angeles.

"What the College Expects in Mathematics from the High School," Prof. Paul Arnold, University of Southern California, Los Angeles.

"Bacteriology Teaching in the High School," Dr. H. S. Reed.

Miss Pierson, Chairman of the Committee on General Science Credits, presented the following resolution, which was unanimously adopted:

"After careful study of the interests and abilities of the pupils of the first two years in the high school, we find that the subject of biology is in general better adapted to their needs than any of the more specialized biological sciences. It is our belief that this subject as now taught in California schools is fully the equal of any other subject taught in the same grades, both as regards mental training given and scientific knowledge imparted.

"We therefore respectfully request that this subject be placed on the regular list of entrance subjects of the University of California."

In addition to the regular program, a visit to the Solar Observatory at Pasadena was enjoyed by many of the members.

C. P. Lyon, *Secretary.*

BOOKS RECEIVED.

Bill's School and Mine, by William S. Franklin, South Bethlehem, Pa. Pages vii+102. 13x18.5 cm. Paper. 1917. $1.00. Franklin, MacNutt & Charles, publishers, South Bethlehem, Pa.

Preliminary Mathematics, by F. E. Austin, Hanover, N. H. Pages 169. 12.5x19.5 cm. Cloth. 1917. $1.20. F. E. Austin, Hanover, N. H.

The Theory of Evolution, by William B. Scott, Princeton University. Pages ix+183. 13.5x19.5 cm. Cloth. 1917. $1.00. The Macmillan Company, New York.

Radioactivity, by Francis P. Venable, University of North Carolina. Pages vii+54. 12.5x18cm. Cloth. 1917. D. C. Heath & Company, Boston, Mass.

Forty-eighth Annual Insurance Report—The State of Illinois, by Rufus M. Potts, Insurance Superintendent. Pages 431. 16x22.5 cm. Cloth. 1916. Springfield, Ill.

Manual Training—Play Problems, by William S. Marten, State Normal School, San Jose, Cal. Pages xxvi+147. 16+24 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

The Theory of Measurements, by Lucius Tuttle, Jefferson Medical College. Pages xiv+303. 14x20.25 cm. Cloth. 1916. $1.25. Jefferson Laboratory of Physics, Philadelphia.

Princeton Stories, by Jesse L. Williams. 319 pages. 13x19 cm. Cloth. Charles Scribner's Sons, New York City.

BOOK REVIEWS.

Introduction to Inorganic Chemistry, by Alexander Smith, Professor of Chemistry and Administrative Head of the Department of Chemistry in Columbia University, New York. Third edition. Rewritten. Pages xiv+925. Illustrated. Cloth. 1917. The Century Co., New York.

This new edition follows quite closely the order of the former editions but the chapter on the oxygen acids of chlorine has been placed further on in the book than formerly. This was done on account of the difficulty of the chapter. The text has been brought up to date and the earlier chapters have been rewritten and greatly improved, especially in their method of approach to what is to many a difficult subject. Many more applications of chemistry have been introduced and there have been added, for the use of teachers and advanced students, many paragraphs in fine print. These paragraphs discuss the various topics from different

angles and supplement and enrich them. The new book has been made more compact than the old one by the use of thinner paper and narrower margins. F. B. W.

Applied Chemistry—A Laboratory Manual for Elementary Students, by Frederic B. Emery, B. A., M. A., Harrison Technical High School, Chicago, Elizabeth W. Miller, Ph. B., M. A., College of Education, University of Chicago, and Charles E. Boynton, B. A., M. D., Waller High School, Chicago. Pages vi+212. 27.5x20x1.5 cm. Diagrams. Cloth. 1917. Lyons and Carnahan, Chicago, New York.

The special features of this new manual of chemistry as outlined by the authors are: First, the reduction of the amount of mechanical labor required of the pupil in making his notebook. This reduction is accomplished by combining the manual and notebook in one volume. As will be noticed from the measurements above, this makes a rather large volume. All necessary drawings are provided in the book so that no time is to be spent by the pupil in making diagrams. Blank spaces are left after all questions for the required answers or equations. The authors believe that the main emphasis should be placed on *chemistry* rather than upon penmanship, skill in drawing, and accuracy in spelling, although they recognize the value of all these accomplishments.

A second merit of the book consists in the clarity of the directions. The time of the teacher will hence not be taken up in explaining to the pupils what they are to do.

The content of the manual is divided into four general groups. The first contains forty-seven general inorganic experiments upon the nonmetals and the metals. The second section has fifty-two experiments in the testing of foods. This section is intended for girls who are studying domestic science and its use should follow a semester of general chemistry. The third section contains fifteen special experiments of a technical character, such as tests of the hardness of water, of soaps, of textiles, coal analysis, etc. Part four is devoted to a brief treatment of qualitative analysis. The manual is intended primarily to be used with the text by the same authors but may be used with any text. F. B. W.

Bill's School and Mine, by William S. Franklin, South Bethlehem, Pa. Pages vii+102. 13×18.5 cm. Paper. 1917. $1.00. Franklin, MacNutt & Charles, publishers, South Bethlehem, Pa.

This is a book which every father who was raised in the country near the old swimmin' hole, near the skating pond, near the walnut and chestnut woods, where the red apples grew, and where the pitch holes and "thank you ma'ams" were numerous in the winter, should read to his boys as he instructs them in nature's school and tells them what he used to do, and how he used to do the chores before he went to school, and how he learned in nature's laboratory the things that it is practically impossible for the boy in this day and age to understand and appreciate as did the fathers and grandfathers of more than forty or fifty yearsago. The author surely has a facile pen, and he depicts the old-fashioned country life as it really did exist. It is a book that demands a wide and extensive sale.

C. H. S.

Radioactivity, by Francis P. Venable, University of North Carolina. Pages vii+54. 12.5×18 cm. Cloth. 1917. D. C. Heath & Company, Boston, Mass.

A splendid little book which should be carefully read by all people who are interested in things connected with this phase of science. It is written so that the science men in other lines of work, and the laymen, too, for that matter, may read and understand. C. H. S.

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School and Home Education, Bloomington, Ill.
School Bulletin, Syracuse, N. Y.
School Century, Oak Park, Ill.
School Education, Minneapolis, Minn.
School News, Taylorville, Ill.
SCHOOL SCIENCE AND MATHEMATICS, CHICAGO, ILL.
Sierra Educational News, San Francisco, Cal.
Southern School Journal, Lexington, Ky.
Teachers' Monograph, Brooklyn, N. Y.
Texas School Journal, Dallas, Texas.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison, Wis.

Manual Training—Play Problems, by William S. Marten, State Normal School, San Jose, Cal. Pages xxvi+147. 16×24 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

This is a book which has been prepared by one who is without question a past master in the knack of manual training as it is applied to youngsters in their teens. The author has prepared a book of such a comprehensive nature that it can be used as a text in almost any school below the grade of the high school, for actual practical work with boys and girls. It will aid in developing them so that they will be able to use to advantage, not only to themselves and their home, but to the community as well, the knowledge that they have gained, and the skill and discipline which naturally come from intensive training. The author has ingeniously coupled the idea of "constructive play" with the idea that the youngsters are really having fun when they are doing things that are worth while.

It is a practical book from cover to cover, and should be in all elementary schools where manual training and object training are taught. It is profusely illustrated, not only with half tones, but with drawings. The drawings of objects are made to scale. The descriptions are splendid. There will be no difficulty for the pupil and teacher to construct the article from the drawings presented. C. H. S.

The Theory of Evolution, by William B. Scott, Princeton University. Pages ix–183. 13.5×19.5 cm. Cloth. 1917. $1.00. The Macmillan Company, New York.

This particular book is one that should be read and studied by those who wish to know the truth concerning the evolutionary doctrine. It is by no means an exhaustive treatment of the subject, but it presents evidence in such a way as will create within the mind of the reader a desire to investigate further in the subject. There is but very little of a technical nature in the book, and the style and diction are of such a nature as will cause not only science men but laymen as well to be interested. C. H. S.

Elementary Algebra, by Elmer A. Lyman, Professor of Mathematics, in the Michigan State Normal College and Albertus Darnell, Head of the Department of Mathematics, Central High School, Detroit, Mich. Pages vii+503. 13x19 cm. 1917. American Book Company, New York.

To provide a complete course in elementary algebra that will satisfy the requirements of courses of study in various states and of the College Entrance Board is the object of this book. Problems of every-day life and careful correlation with arithmetic are used to vitalize the subject and afford greater interest. Exercises of undue difficulty and troublesome phases of the subject are omitted; many of the exercises are taken from entrance examination questions set by various colleges and universities. The material is well arranged, and the pages present a pleasing appearance. H. E. C.

Calculus, by H. W. March and H. C. Wolff, Assistant Professors of Mathematics in the University of Wisconsin. Pages xvi+360. 13x19 cm. $2.00. 1917. McGraw-Hill Book Company, Inc., New York.

A working course in calculus that from the beginning deals with real problems and uses them to show how in mathematics the language and methods of thought fit naturally into the expression and derivation of scientific laws and natural concepts is presented in this book. To emphasize the mode of thought so that students will be able and willing to

use their calculus after they get out of college is the laudable purpose of the authors, and it seems as if they have made a wise choice of material and method to secure the results they desire. There seems to be little chance of a student failing to get a clear idea of a derivative and its use.

Integration is introduced immediately after the differentiation of algebraic functions, so that many of the most important applications of calculus occur early in the course and constantly recur. The subjects of center of gravity and moments of inertia receive full treatment, and problems in geometry, physics, and mechanics are freely used. A chapter on solid analytic geometry enables students who have not studied this subject to work problems involving solids. H. E. C.

Problems in the Mathematical Theory of Investment, by G. R. Clements, Instructor in Mathematics in the University of Wisconsin. Pages iii+24. 13x19 cm. 32 cents. 1917. Ginn and Company, Boston.

This list of one hundred problems furnishes some excellent practical applications of the theory of investment. The problems, dealing with (a) a single payment, or several payments, irregular either in amount or in frequency of payment, or (b) an annuity, will be of great service in courses dealing with this subject. H. E. C.

Synthetic Projective Geometry, by D. N. Lehmer, Associate Professor of Mathematics in the University of California. Pages xiii+123. 13x19 cm. 96 cents. 1917. Ginn and Company, Boston.

In the preface the author states his opinion that the subject of synthetic projective geometry will in the near future be taught in the secondary schools. This book will certainly hasten that day, for it presents the subject in a most interesting and stimulating way. No knowledge of mathematics beyond high school algebra and geometry are presupposed. The subjects treated include: Correspondences; point-rows and pencils of the first and second order; Pascal's and Brianchon's theorems, with their many consequences; duality; poles and polars; and involution, besides metrical developments. The closing chapter, of twenty pages, gives a most vivid historical account of the development of the subject and reveals the value of a course in pure geometry. H. E. C.

Analytic Geometry and Calculus, by F. S. Woods and F. H. Bailey, Professors of Mathematics in the Massachusetts Institute of Technology. Pages xi+516. 15x21 cm. 1917. Ginn and Company, Boston.

Ten years ago a two-volume *Course in Mathematics for Students of Engineering and Applied Sciences* was issued by the authors, in which the material, given in courses in algebra, analytic geometry, calculus, and differential equations, was included. The traditional division of mathematics into distinct subjects was disregarded, and the principles of each subject were introduced as needed and the subjects developed together. Rather slowly, but surely, it is being recognized that this plan gives students a better grasp of mathematical principles and enables them to use the method best adapted to the solution of problems that come to them later.

The present volume is a condensation and rearrangement of the former work and presents many new methods of treatment. In the first part of the book all methods for the graphical representation of functions of one variable are brought together, and the principles of calculus are introduced early in the discussion of slope and area. Later the analytic geometry of three dimensions is treated, when required for the study of functions of two variables. Many of the two thousand problems are new. The book furnishes material for a two-year college course, and will no doubt be widely used. H. E. C.